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ENGINEERING:

An Illustrated Weekly Journal.

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See Page 89.
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Specification and Workmanship equal to Main Line Locomotives.
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See Advertisement, page 71, Jan. 4.

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See Advertisement, page 82. 1872

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See Advertisement, page 51, Jan. 4.

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Capacity 3 tons and 1½ tons,
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See Full Page Advt., page 46, Jan. 4.

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See advert., page 80, Jan. 4. 8195

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See half-page Advertisement, page 68, Dec. 21.

The Manchester Steam Users' ASSOCIATION.

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The Laboratory will be open on Wednesday evenings during January and February for students desiring instruction in Fuel Calorimetry and Pyrometry, and for more advanced students capable of independent work.

For further information apply to THE REGISTRAR, The University, Leeds. C 549

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Engineering Salesmanship

and SALES MANAGEMENT.—Write for brochure describing our special Course of training for posts of unlimited scope in this lucrative field.—DIRECTOR, Institute of Engineering Salesmanship, 333, Oxford Road, Manchester. 1879

TENDERS.

PORT OF BRISTOL.

FLOATING PNEUMATIC ELEVATOR.

The Docks Committee are prepared to receive

Tenders for the Construction

of a FLOATING PNEUMATIC GRAIN ELEVATOR, to handle 150 tons per hour, erected at the Avonmouth Docks, Bristol.

On and after Monday, the 7th day of January, 1924, a copy of the Form of Tender, General Conditions, Specification, Schedule of Prices, and a copy of the Contract Drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the Bristol Docks Committee, 19, Queen Square, Bristol, to whom all cheques must be made payable. The deposit of £5 will be returned hereafter to all *bona fide* Tenderers.

Tenders must be enclosed in a sealed envelope, endorsed "Tender for Floating Pneumatic Elevator," and addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m. on Monday, the 18th day of February, 1924.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACE, Engineer, Port of Bristol.

Chief Engineer's Office, Avonmouth Docks, 1st January, 1924. C 518

MINISTRY OF TRANSPORT.

CONSTRUCTION OF NEW ARTERIAL ROADS.

The Minister is prepared to receive

Tenders for the Earth-

WORK, BRIDGES and DRAINAGE WORK in connection with the construction of the New Arterial Roads known as:—

Orpington By-Pass.
Bexleyheath By-Pass.
West Wickham and Farnborough By-Passes.

Specifications, Bills of Quantities, Forms and Conditions of Tender may be obtained from the Chief Engineer Arterial Roads Department, Ministry of Transport, 7, Whitehall Gardens, S.W.1, upon payment of a deposit of Twenty-five pounds in respect of each scheme. This amount will be returned to the Tenderer, if his Tender is a *bona fide* one and has not been withdrawn prior to the definite acceptance of a Tender by the Minister.

The Drawings and Conditions of Contract may be inspected at the Ministry, and copies of the Specification, Bill of Quantities, etc., will be available on and after the 12th January, 1924.

Tenders on the official form and accompanied by a fully priced Bill of Quantities, must be submitted separately in respect of each scheme, and enclosed in a sealed envelope endorsed "Tender for Orpington By-Pass," "Bexleyheath By-Pass," "West Wickham and Farnborough By-Passes," as the case may be.

The Minister does not bind himself to accept the lowest or any Tender

Tenders must reach the undersigned by ten a.m. on the 28th day of January, 1924.

Dated this second day of January, 1924.

(Sd.) H. H. PIGGOTT, Assistant Secretary.

Ministry of Transport, C 571

The Air Ministry have

FOR SALE a number of DIRECT-COUPLED GENERATING SETS, by Robey & Co., and Electrical Construction Co., SWITCHBOARDS, TRANSFORMERS, and ELECTRICALLY DRIVEN PUMPING SETS.

The Plant can be viewed and forms of tender obtained on application being made to:—

THE CHIEF STORES & ACCOUNTS OFFICER, Air Ministry W. & B. Stores Depot, Belmoral Road, Watford. C 570

SOUTH AFRICAN RAILWAYS AND HARBOURS ADMINISTRATION.

ELECTRIFICATION OF CAPETOWN-SIMONSTOWN LINES.

Tenders are Invited for

PLANT in connection with the Electrification of the above Railways, as follows:—

(1) MOTOR BOGIES.
(2) ELECTRICAL EQUIPMENT OF COACHES.

Separate Specifications and Forms of Tender for each of the above sections may be obtained at the Office of the HIGH COMMISSIONER FOR THE UNION OF SOUTH AFRICA, Trafalgar Square, London, W.C. 2, on and after the 12th January, 1924, or the Office of the General Manager, Johannesburg, on and after 26th January, 1924.

The Consulting Engineers, to whom applications for any further technical information may be made, are Messrs. MERZ & MCLELLAN, 32, Victoria Street, London, S.W. 1.

The charge for each specification is £5 5s. for the first copy, and £2 2s. each for any further copies. Sums paid for any number of each specification up to three will be refunded on receipt of *bona-fide* Tenders. Sums paid for copies of specifications beyond three of each will not be refunded.

Sealed Tenders, marked "Tender for Electrification of Capetown-Simonstown Lines," are to be addressed to the HIGH COMMISSIONER FOR THE UNION OF SOUTH AFRICA, and lodged at his office in London by Noon on the 8th March, 1924.

The Administration does not bind itself to accept the lowest or any Tender. C 536

UNION OF SOUTH AFRICA.

ELECTRICITY SUPPLY COMMISSION.

ELECTRIFICATION OF SOUTH AFRICAN RAILWAYS—SUPPLY OF POWER.

Pursuant to the Electricity Act, 1922, the Electricity Supply Commission Hereby Invites

Tenders for the Establish-

MENT and WORKING of a proposed UNDERTAKING for the SUPPLY of ELECTRICITY to the Railways in the neighbourhood of Capetown Forms of Tender, Conditions of Contract and Specifications may be obtained on or after January 12th, 1924, from:—

The Office of the ELECTRICITY SUPPLY COMMISSION, 84, Marshall Street, Johannesburg, or
The Office of the Consulting Engineers to the Commission, Messrs. MERZ & MCLELLAN, 32, Victoria Street, London, S.W 1.

The charge for Specifications is £10 10s. each for the first two copies and £5 5s. each for any further copies. The amount paid for the first three copies will be refunded on receipt of a *bona fide* Tender.

Intending Tenderers desiring information relative to the proposed undertaking may communicate with the Electricity Supply Commission, Johannesburg, or with the Consulting Engineers, at the above addresses

Sealed Tenders, in duplicate, addressed to the Electricity Supply Commission and marked "Tender for Supply to Capetown Suburban Railways," must be lodged by Noon, on March 8th, 1924, at the Office of the Electricity Supply Commission, 84, Marshall Street, Johannesburg, South Africa, or, alternatively, at the Office of the High Commissioner for the Union of South Africa, London, England.

The Commission does not bind itself to accept the lowest or any Tender.

A. C. McCOLM, Secretary. C 537

UNION OF SOUTH AFRICA.

ELECTRICITY SUPPLY COMMISSION.

ELECTRIFICATION OF SOUTH AFRICAN RAILWAYS—SUPPLY OF POWER.

The Electricity Supply Commission invites

Tenders as Follows, for

BUILDINGS and PLANT required in connection with an undertaking for the Supply of Electricity to the Railways in the neighbourhood of Capetown:—

1. Steel Frame Buildings for Power Station.
2. Boiler House Equipment.
3. Coal and Ash-Handling Plant.
4. Turbo Alternators.
5. Condensing Plant.
6. Power Station Switchgear.
7. Substation Switchgear.
8. Transformers for Step-up Substation and Power Station.
9. Substation Equipments.
10. Cables.

Separate Specifications and Forms of Tender for each of the above sections may be obtained on or after 12th January, 1924, from the Office of the ELECTRICITY SUPPLY COMMISSION, 84, Marshall Street, Johannesburg, or from the Office of the Consulting Engineers to the Commission, Messrs. MERZ & MCLELLAN, 32, Victoria Street, London, S.W.1.

Application may be made to the Commission or to the Consulting Engineers for further information.

Contractors may Tender for all or any of the above sections.

The charge for Specifications relating to each section of the work is £10 10s. for the first two copies, and £2 2s. each for any further copies. Sums paid for any number of each Specification up to three will be refunded on receipt of a *bona fide* Tender.

Sealed Tenders, in duplicate, marked "Tender for Plant for Capetown," must be lodged by Noon, on 8th March, 1924, with Messrs. MERZ & MCLELLAN, 32, Victoria Street, London, England, or, alternatively, with the Electricity Supply Commission, 84, Marshall Street, Johannesburg, South Africa.

The Commission does not bind itself to accept the lowest or any Tender.

A. C. McCOLM, Secretary. C 538

BRADFORD CORPORATION TRAMWAYS.

RAILLESS ELECTRIC VEHICLES.

The Tramways Committee of the Bradford Corporation invite

Tenders for the Supply of

SIX RAILLESS ELECTRIC VEHICLES AND SPARE PARTS.

Schedules and Conditions of Tender may be had on application to Mr. R. H. WILKINSON, M.Inst.T., General Manager, 7, Hall Ings, Bradford.

The Contract will be let subject to the Fair Contracts Clauses of the Corporation.

Tenders endorsed "Railless Electric Vehicles," to be sent to the undersigned not later than 28th January, 1924.

The lowest or any Tender will not necessarily be accepted.

N. L. FLEMING, Town Clerk, Town Hall, Bradford, January, 1924. C 583

COUNTY BOROUGH OF SALFORD.

HEALTH DEPARTMENT.

LADYWELL SANATORIUM.

Tenders are Invited for a

COMPLETE COOKING and KITCHEN EQUIPMENT at the above Sanatorium.

Specification and full particulars may be obtained on application to the Medical Officer of Health, Dr. OSBORNE, at 143, Regent Road, Salford, and drawings of the buildings may be inspected on application at the Offices of the Electricity Department, Frederick Road, Salford.

Sealed Tenders, endorsed "Cooking and Kitchen Equipment at Ladywell" and addressed to the Chairman of the Health Committee, should be delivered at 143, Regent Road, Salford, not later than Twelve noon, on Monday, 4th February, 1924.

The Corporation do not bind themselves to accept the lowest or any Tender.

L. C. EVANS, Town Clerk. C 627

TO ENGINEERS AND OTHERS.

THE METROPOLITAN ASYLUMS BOARD INVITE SEPARATE

Tenders for

(A). THE INSTALLATION of a TWO ROLLER IRONING MACHINE at Goldie Leigh Homes, Abbey Wood, S.E. 2.
(B). The CONVERSION of TWO STEAM BOILERS from Mechanical Stoking to Hand Firing at Queen Mary's Hospital for Children, Carshalton, Surrey.

In accordance with Specification and Drawing prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawing and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Tuesday, 15th January, 1924, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona-fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawing have been returned. Tenders addressed as noted on the Form must be delivered at the Office of the Board not later than 2.30 p.m, on Wednesday, 30th January, 1924.

(By Order) G. A. POWELL, Clerk to the Board. C 608

TYNE IMPROVEMENT COMMISSION.

THREE 2½-TONS LATTICE STEEL DERRICKS FITTED WITH ELECTRIC WINCHES.

THE TYNE IMPROVEMENT COMMISSIONERS are prepared to receive

Tenders for the Supply and

ERECTION at their Engineering Yard, Howden-on-Tyne, of THREE 2½-TONS LATTICE STEEL DERRICKS fitted with Electric Winches.

Copies of the Form of Tender, Conditions of Contract, Specification and Drawing may be obtained on application to the undersigned on payment of a deposit of £2 2s., which will be returned on receipt of a *bona fide* Tender.

Tenders in sealed envelopes endorsed on the cover, "Tender for Lattice Steel Derricks," must be addressed to the Chairman, Dredging and River Works Committee, and delivered at the undermentioned Offices not later than Noon, on Friday, the 25th day of January, 1924.

The Commissioners do not bind themselves to accept the lowest or any Tender.

By Order, ALBERT BLACKLOCK, Secretary.

Tyne Improvement Commission Offices, Bewick Street, Newcastle-upon-Tyne. 7th January, 1924. C 555

TO ENGINEERS, ELECTRICIANS AND OTHERS.

The METROPOLITAN ASYLUMS BOARD invite separate

Tenders for :—

(A) The INSTALLATION of a 144 TUBE ECONOMISER,
(B) The INSTALLATION of a NEW CONTINUOUS DRYING MACHINE,
(C) ENGINEERING WORK for New Central Boiler House.
(D) REVISING THE LAUNDRY ENGINEERING ARRANGEMENTS,
(E) INSTALLING ELECTRIC LIGHT & POWER WIRING in Boiler House and Laundry.
(F) The COVERING OF BOILERS, STEAM FEED & SUCTION MAINS, etc.,

with non-conducting composition, at the South-Western Fever Hospital, Landor Road, Stockwell, S.W.9, each in accordance with specification and drawings prepared by Mr. T. COOPER, M.Inst.C.E. M.I.Mech.E., Engineer-in-Chief. The Specification, Drawings and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on an after Ten a.m. on Thursday, 10th January, 1924, and can then be obtained upon payment of a deposit of £1 in respect of each work. The amount of the deposit will be returned only after the receipt of a *bona fide* tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than 2.30 p.m., on Wednesday, 30th January, 1924.

(By Order) G. A. POWELL, Clerk to the Board. C 568

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C.2, invite

Tenders for :—

4-WHEEL COVERED WAGONS. Fee £1.

Tenders are due by Bieven a.m. on 5th February, 1924. Tender forms obtainable at above address. FEES NOT RETURNABLE. C 628

The Director-General,

India Store Department, Branch No. 17, Belvedere Road, Lambeth, S.E.1, REQUIRES:—1 DOG SPIKES.
2 AXLES for Locomotives.

Tenders due on the 22nd January, 1924, for No. 1, and on the 29th January, 1924, for No. 2.

Tender Forms obtainable from above. C 612

BENGAL-NAGPUR RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for :—

(A) 276 tons WROUGHT IRON BARS. (Grade "A.")
(B) 2000 CAST IRON AXLEBOX BEARINGS.
(C) 121 tons MILD STEEL SHEETS.
(D) 256 tons SPRING STEEL.
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Tenders must be submitted not later than NOON, on Monday, 21st January, 1924.

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By Order of the Board. R. C. VOLKERS, Secretary. C 574

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THE ELEMENTS OF THE LANCHESTER-PRANDTL THEORY OF AEROPLANE LIFT AND DRAG.*

(*Continued from page* 3.)

IN the preceding article it was pointed out that at a great distance from an aeroplane, the motion of the air must be sensibly the same as that of a perfect fluid, and that a perfect fluid if itself at rest can exercise neither lift not drag on an obstacle moving through it. The explanation of the large lift actually observed is, therefore, to be sought in the fact that the surface friction experienced by the air moving over the wing surfaces, produces vortex lines at these surfaces. Each of these vortex lines impresses a circulation on the surrounding air, and the net circulation at any point is the resultant of the whole group, each component being taken with its proper sign. Hence at a great distance from the plane the circulation can be considered as due to one resultant vortex line, representing the core of a Rankine free circular vortex.

Take any stream line in such a vortex, as, for example, the circle I J H, Fig. 5. page 2 *ante*. If we consider the area bounded by this to be solidified, but to be spinning at such a rate that its surface velocity is the same as before, the motion of the fluid outside the boundary I J H will be unaffected. If b be the radius of this circle, the tangential velocity there is $\frac{\Gamma}{2\pi a}$, where Γ denotes the "circulation" as explained on page 2 *ante*. Hence if ω denote the angular velocity of the solidified cylinder we must have

$$b\,\omega = \frac{\Gamma}{2\pi a}.$$

Hence the angular velocity of the solid rod is equal to the circulation divided by twice the area of the cross-section of the bar.

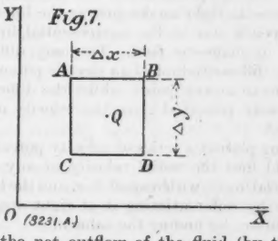
So far as the flow of the air at a great distance from an aeroplane is concerned we may, from the mathematical standpoint, replace an aeroplane by a rotating cylinder which is thus responsible for the circulation to which the lift is proportional. We propose in this article to determine the flow of a perfect fluid roupd such a cylinder. The importance of this, at first sight, academical problem lies in the fact, that having determined by calculation the stream lines round this cylinder we can by a simple graphic construction find from these the stream lines round forms which closely approximate to actual wing sections, and which therefore are stream line forms for actual fluids, which, of course, the cylinder is not.

It is convenient to consider this rotating cylinder fixed in space and that the air streams past it. Were the cylinder absent this air would have a uniform horizontal velocity $-V$, the minus sign being used because this hypothetical motion of the air is in the opposite direction to the actual motion of the plane. The presence of the cylinder, however, disturbs the stream lines in its neighbourhood, but this disturbance rapidly dies away the further we get from the cylinder. Hence at an infinite distance the fluid may be considered as moving with the uniform velocity $-V$. This will be true whether the cylinder is, or is not, rotating, since the velocity due to the rotation is equal to $\frac{\Gamma}{2\pi r}$, and thus becomes zero when r is infinite. It follows, therefore, that the velocity of the air at infinity is due solely to the translatory motion of the fluid.

The stream lines round a cylinder rotating in still air are the same as for the corresponding vortex line which the cylinder replaces. These stream lines are accordingly circles. If, however, the air is not still, but flowing past the cylinder, the resultant velocity at any point is the graphic sum of the velocity due to the rotating cylinder, and of the velocity which the moving air would have, were the rotation of the cylinder stopped.

To determine the latter, it will be necessary to establish some general propositions, as to the motion of a perfect fluid in two-dimensional flow. We may conveniently take the stream of fluid to be 1 cm. deep. Consider a little rectangle A B C D, having its centre at Q, Fig. 7, and let the side A B be Δx cm. long, whilst A C is Δy cm. long. We assume further that Δx and Δy are so small that their squares and products may be neglected. At Q (the centre of the rectangle) the fluid has some absolute velocity, the horizontal component of which we shall denote by u and the vertical component by v.

Then assuming the fluid to be incompressible* we note that in the steady state, as much fluid must leave the rectangle per second as enters it. Now the horizontal component velocity varies in general from point to point. At Q it is u, but we require to know its average value at the face A C in order to find what volume of fluid enters here per second. The distance of A C from Q is $-\frac{\Delta x}{2}$ hence substituting this value for h in Taylor's theorem we find that at the face A C the average horizontal component velocity will be $u - \frac{\partial u}{\partial x}\cdot\frac{\Delta x}{2}$, cm. per second, and thus the quantity of fluid entering by the face A C is $\left(u - \frac{\partial u}{\partial x}\cdot\frac{\Delta x}{2}\right)\Delta y$ c.c per second. In a similar way we see that the quantity leaving by the face B D is $\left(u + \frac{\partial u}{\partial x}\cdot\frac{\Delta x}{2}\right)\Delta y$ c.c per second.



Hence the net outflow of the fluid (by the two faces considered) will be the difference of these two, or $\frac{\partial u}{\partial x}\,\Delta x\,.\,\Delta y$.

Similarly the net outflow in the direction of the axis OY is $\frac{\partial v}{\partial y}\,\Delta x\,\Delta y$.

Adding this to the foregoing we get

$$\left[\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y}\right]\Delta x\,\Delta y$$

as the net outflow per second.

Since, however, in the steady state as much fluid leaves the rectangle as enters it, this net outflow is zero. This gives us

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad . \quad . \quad . \quad (1)$$

This partial differential equation must be satisfied by any expression we deduce for the velocity of an incompressible perfect fluid.

Again the momentum generated per second in the fluid as it passes through the rectangle must be numerically equal to the accelerating forces which act on it during its passage.

If p be the pressure (in dynes per square centimetre) at the point Q, its average value at the face A C will be (by Taylor's theorem) $p - \frac{\partial p}{\partial x}\cdot\frac{\Delta x}{2}$ and the total force at this face tending to accelerate the horizontal velocity of the fluid will be $\left(p - \frac{\partial p}{\partial x}\cdot\frac{\Delta x}{2}\right)\Delta y$.

At the opposite face the average pressure will be $p + \frac{\partial p}{\partial x}\cdot\frac{\Delta x}{2}$ and the total force tending to retard the horizontal flow of the fluid will be $\left(p + \frac{\partial p}{\partial x}\cdot\frac{\Delta x}{2}\right)\Delta y$.

Hence the resultant force tending to increase the horizontal momentum of the fluid will be the difference of these two expressions, or $-\frac{\partial p}{\partial x}\Delta x\,\Delta y$.

We have to equate this to the increase effected per second in the horizontal momentum of the fluid passing through the rectangle.

The volume of fluid entering at the face A C is $\left[u - \frac{1}{2}\frac{\partial u}{\partial x}\Delta x\right]\Delta y$ cc., and if ρ be its density in grammes per cubic centimetre, the horizontal momentum entering the rectangle by this face is $\rho\left[u - \frac{1}{2}\frac{\partial u}{\partial x}\cdot\Delta x\right]^2\Delta y$, which, if we neglect the square of Δx, becomes

$$\rho\left(u^2 - u\frac{\partial u}{\partial x}\Delta x\right)\Delta y.$$

Similarly the horizontal momentum leaving each second by the face B D is $\rho\left(u^2 + u\frac{\partial u}{\partial x}\Delta x\right)\Delta y$.

The net increase in the horizontal momentum entering and leaving by these faces is therefore

$$2\,\rho\,u\frac{\partial u}{\partial x}\Delta x\,\Delta y$$

This, however, is not the whole of the increase in the horizontal momentum, since the fluid which enters the rectangle by the face C D also possesses horizontal momentum, as does that which leaves by the face A B.

The volume entering at the face C D is $\left(v - \frac{\partial v}{\partial y}\cdot\frac{\Delta y}{2}\right)\Delta x$ cc. per sec. and the horizontal component of its velocity is $u - \frac{\partial u}{\partial y}\cdot\frac{\Delta y}{2}$. Hence the horizontal momentum carried in at this face is

$$\rho\left(u - \frac{\partial u}{\partial y}\cdot\frac{\Delta y}{2}\right)\left(v - \frac{\partial v}{\partial y}\cdot\frac{\Delta y}{2}\right)\Delta x.$$

If we neglect the square of Δy this becomes

$$\rho\left(uv - u\frac{\partial v}{\partial y}\cdot\frac{\Delta y}{2} - v\frac{\partial u}{\partial y}\cdot\frac{\Delta y}{2}\right)\Delta x.$$

Similarly the horizontal momentum leaving by the opposite face A B is

$$\rho\left(uv + u\frac{\partial v}{\partial y}\cdot\frac{\Delta y}{2} + v\frac{\partial u}{\partial y}\cdot\frac{\Delta y}{2}\right)\Delta x.$$

Hence the net increase in the horizontal momentum of the fluid entering and leaving by the faces in question is

$$\rho\left(u\frac{\partial v}{\partial y} + v\frac{\partial u}{\partial y}\right)\Delta y\,\Delta x.$$

Adding this to the increase in the horizontal momentum entering and leaving by the faces A C and A D, we get as the total increase per second in the horizontal momentum, the expression

$$\rho\left(2u\frac{\partial u}{\partial x} + u\frac{\partial v}{\partial y} + v\frac{\partial u}{\partial y}\right)\Delta y\,\Delta x.$$

This must be equal to the net force producing horizontal acceleration, which as shown above is $-\frac{\partial p}{\partial x}\,.\,\Delta x\,.\,\Delta y$. We thus get the equation

$$-\frac{1}{\rho}\cdot\frac{\partial p}{\partial x} = 2u\frac{\partial u}{\partial x} + u\frac{\partial v}{\partial y} + v\frac{\partial u}{\partial y}.$$

But from equation (1) *ante* $\frac{\partial v}{\partial y} = -\frac{\partial u}{\partial x}$.

Making this substitution gives:

$$-\frac{1}{\rho}\frac{\partial p}{\partial x} = u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y} \quad . \quad . \quad (2)$$

By symmetry we can write down at once the corresponding expression derived from a consideration of forces and momenta parallel to the axis of Y, viz.:

$$-\frac{1}{\rho}\frac{\partial p}{\partial y} = v\frac{\partial v}{\partial y} + u\frac{\partial v}{\partial x} \quad . \quad . \quad (3)$$

Equations (2) and (3) must also be satisfied by any expression which purports to represent the distribution of velocity in an incompressible perfect fluid.

Still another equation is provided by Bernoulli's principle, which, as expressed in C.G.S. units, runs:

$$\frac{p}{\rho} + \frac{u^2}{2} + \frac{v^2}{2} = \text{constant}.$$

Differentiating this leads to:

$$-\frac{1}{\rho}\cdot\frac{\partial p}{\partial x} = u\frac{\partial u}{\partial x} + v\frac{\partial v}{\partial x}$$

and subtracting this from (2) we get

$$v\frac{\partial u}{\partial y} - v\frac{\partial v}{\partial x} = 0.$$

which on division by v, reduces to

$$\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x} = 0 \quad . \quad . \quad . \quad (4)$$

* The definition of "circulation" as given on page 2 *ante*, is Clifford's as set forth on page 194 of his "Elements of Dynamic." Many other writers confine the term circulation to the case where the contour is a closed curve, and use the term "flow" in other cases.

* This is permissible since the load carried by an aeroplane does not exceed some 20 lb. per square foot as a maximum, whilst the normal pressure of the air is 2,116 lb. per square foot. Hence the maximum actual change in density is very small.

Now any expression which satisfies (1) and (4) will also satisfy (2) and (3), and Bernoulli's equation, and hence the determination of the velocity distribution in the two-dimensional flow of an incompressible perfect fluid is reduced to the problem of finding expressions which will satisfy simultaneously the partial differential equations:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad . \quad . \quad . \quad (1)$$

$$\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x} = 0 \quad . \quad . \quad . \quad (4)$$

where u denotes the component velocity along the axes of X and v the component velocity along the axis of Y.

The solution of such equations is inherently a matter of guesswork. Certain assumptions are made, and tested, to see if they will work. If they do, the particular problem in question is solved. If they fail, another guess is made and tried in its turn. Naturally in the course of time a great many successful guesses have been accumulated and classified.

In the present instance we shall make the assumption that $u = \frac{\partial \phi_1}{\partial x}$ and $v = \frac{\partial \phi_1}{\partial y}$, where ϕ_1 is some function of x and y. If we introduce these values into equation (4) we get the identity:*

$$\frac{\partial}{\partial y} \cdot \frac{\partial \phi_1}{\partial x} - \frac{\partial}{\partial x} \cdot \frac{\partial \phi_1}{\partial y} = 0,$$

So that this equation is satisfied whatever ϕ_1 may be. It is, however, requisite that equation (1) be also satisfied, and this condition can only be met if ϕ_1 belongs to a certain class of function. Thus substituting in equation (1) we get

$$\frac{\partial}{\partial x} \cdot \frac{\partial \phi_1}{\partial x} + \frac{\partial}{\partial y} \cdot \frac{\partial \phi_1}{\partial y} = 0.$$

which is commonly written in the form $\nabla^2 \phi_1 = 0$. This is the famous equation of Laplace, which makes its appearance in every department of mathematical physics.

Any function whatever which satisfies this equation corresponds to some possible flow of an incompressible perfect fluid. The problem of finding the motion of such a fluid round any obstacle resolves itself accordingly into discovering values of ϕ_1, which satisfy Laplace's equation, and at the same time give correct values for the velocity at the surface of the obstruction and also at an infinite distance away. At such infinite distance the disturbance of the stream lines caused by the obstacle has died away and the stream lines are all parallel to each other and to the axis of X.

Laplace's equation when expressed in polar co-ordinates† becomes:

$$\frac{\partial^2 \phi_1}{\partial r^2} + \frac{1}{r} \cdot \frac{\partial \phi_1}{\partial r} + \frac{1}{r^2} \cdot \frac{\partial^2 \phi_1}{\partial \theta^2} = 0 \quad . \quad (6)$$

The general method of solving this equation is to assume that values of ϕ_1 can be expressed as the product of two functions, one of which is a function of r only and the other a function of Θ only; that is, we assume $\phi_1 = \mathrm{R}\,\Theta$ where R denotes a function of r and Θ a function of θ. There are an infinite number of such which will satisfy (6), and to find the one we require it is necessary to consider the physical conditions of the flow.

Now in the case under consideration, as we get further and further away from the obstacle, the stream lines become more and more parallel to the axis of reference and the radial velocity more and more nearly equal to $-\mathrm{V}\cos\theta$. When r is infinite this approximation becomes exact, so we shall make the assumption that the function Θ is $\cos\theta$, and try how it works.

Substituting this value in (6) and dividing the result by $\cos\theta$, we get:

$$\frac{\partial^2 \mathrm{R}}{\partial r^2} + \frac{1}{r} \cdot \frac{\partial \mathrm{R}}{\partial r} - \frac{\mathrm{R}}{r^2} = 0.$$

This equation is obviously satisfied by $\mathrm{R} = \mathrm{A}r$, or $\mathrm{R} = \frac{\mathrm{B}}{r}$, where A and B are arbitrary constants of integration.

We thus get

$$\phi_1 = \left(\mathrm{A}r + \frac{\mathrm{B}}{r}\right)\cos\theta.$$

The radial velocity is $\frac{\partial \phi_1}{\partial r}$, denoting this by w we get:

$$w = \left(\mathrm{A} - \frac{\mathrm{B}}{r^2}\right)\cos\theta.$$

But we know that when r is infinite

$$w = -\mathrm{V}\cos\theta.$$

Therefore $\mathrm{A} = -\mathrm{V}$.

Again, at the surface of the cylinder, the radial velocity is obviously zero, since the fluid can only flow along the surface and not into it. Hence when $r = a$ we have:

$$w = \left(-\mathrm{V} - \frac{\mathrm{B}}{a^2}\right)\cos\theta = 0.$$

$$\therefore \quad \mathrm{B} = -a^2\mathrm{V}.$$

Hence

$$\phi_1 = -\mathrm{V}\left(r + \frac{a^2}{r}\right)\cos\theta \quad . \quad . \quad (7)$$

Such functions as ϕ_1 are known as velocity potentials in analogy to electric or gravitational potentials.

If we plotted down a series of curves giving different numerical values to ϕ_1 we should get a series of equipotential lines. The stream lines cross these at right angles just as the lines of force are perpendicular to the equipotential lines in an electric or magnetic field. The only difference is that the differentiation of an electric potential gives us the force at any point, whilst the differential of the velocity potential gives the velocity of flow at the point.

Having plotted a series of velocity potential lines, we could find the radial velocity at any point by differentiating ϕ_1 with respect to r, and the tangential velocity by differentiating it at right angles to r; that is to say by finding the value of

$$\frac{\partial \phi_1}{\partial s} = \frac{\partial \phi_1}{r\,d\theta}$$

We could then find the resultant velocity at every point of the field of flow, and having done this we could map out the stream lines. There is, however, another and more direct method of doing this, which may be explained as follows:—

We can, of course, transform the value found for ϕ_1 into rectangular co-ordinates. Assume this to be done. Then if we neglect squares of small quantities we have by Taylor's theorem:

$$\Delta\phi_1 = \frac{\partial \phi_1}{\partial x}\Delta x + \frac{\partial \phi_1}{\partial y}\Delta y$$

Along an equipotential, however, $\Delta\phi_1 = 0$. Hence along any such line we have:

$$\frac{\Delta y}{\Delta x} = -\frac{\frac{\partial \phi_1}{\partial x}}{\frac{\partial \phi_1}{d y}} = \frac{d y}{d x}$$

at the limit.

But $\frac{d y}{d x}$ represents the slope of the equipotential line at any point and the stream lines cut these at right angles.

If then $\frac{\partial y^1}{\partial x^1}$ denote the inclination of the stream line at the point considered we must have, by an elementary rule in co-ordinate geometry:

$$\frac{d y^1}{d x^1} = -\frac{d x}{d y} = +\frac{\frac{\partial \phi_1}{\partial y}}{\frac{\partial \phi_1}{\partial x}}$$

But

$$\frac{\partial \phi_1}{\partial y} = v \text{ and } \frac{\partial \phi_1}{\partial x} = u.$$

Hence

$$\frac{d y^1}{d x^1} = \frac{v}{u}.$$

Now if $\psi_1 = f(x\,y)$ be the equation to the stream lines, we have as before:

$$\frac{d y^1}{d x^1} = -\frac{\frac{\partial \psi_1}{\partial x}}{\frac{\partial \psi_1}{\partial y}} = \frac{v}{u}.$$

This will be satisfied if

$$\frac{\partial \psi_1}{\partial x} = -v = -\frac{\partial \phi_1}{\partial y}$$

and

$$\frac{\partial \psi_1}{\partial y} = u = +\frac{\partial \phi_1}{\partial x}.$$

Hence

$$\frac{\partial^2 \psi_1}{\partial x^2} = -\frac{\partial v}{\partial x}$$

$$\frac{\partial^2 \psi_1}{\partial y^2} = +\frac{\partial u}{\partial y}$$

so that

$$\nabla^2 \psi_1 = \frac{\partial u}{\partial y} - \frac{\partial v}{\partial x}$$

But from equation (4) *ante* the right-hand side of this equation is zero, and it follows accordingly that ψ_1 is also a solution of Laplace's equation and may also represent equipotential lines in which case ϕ_1 represents the stream lines.

For example, in Rankine's free circular vortex, the stream lines are circles and the velocity potential lines are radii. On the other hand we may have the case in which the fluid is flowing in radially and disappearing into a "sink" at the point previously occupied by the vortex line. In this case the stream lines are radial and equipotential lines circles.

When two functions of x and y, such as ϕ and ψ are solutions of Laplace's equation and are interrelated so that:

$$\frac{\partial \psi}{\partial y} = \frac{\partial \phi}{\partial x}$$

and

$$\frac{\partial \psi}{\partial x} = -\frac{\partial \phi}{\partial y}$$

they are known as conjugate cylindrics and represent possible stream lines and potential lines for an incompressible perfect fluid.

Any number of such functions can be found, as will be explained in a succeeding article.

Returning to our cylinder we have found that the velocity potential function corresponding to the flow past the cylinder when the latter is stationary was expressed in polar co-ordinates in the form

$$\phi_1 = -\mathrm{V}\left(r + \frac{a^2}{r}\right)\cos\theta.$$

If we express this in rectangular co-ordinates it becomes:

$$\phi_1 = -\mathrm{V}\left(x + \frac{a^2 x}{x^2 + y^2}\right)$$

Whence

$$\frac{\partial \phi_1}{\partial x} = -\mathrm{V}\left(1 + \frac{a^2 y^2 - a^2 x^2}{(x^2 + y^2)^2}\right)$$

But, as shown above,

$$\frac{\partial \phi_1}{\partial x} = \frac{\partial \psi_1}{\partial y}$$

Therefore

$$\psi_1 = -\mathrm{V}\left(y - \frac{a^2 y}{x^2 + y^2}\right)$$

$$= -\mathrm{V}\left(r - \frac{a^2}{r}\right)\sin\theta \quad . \quad . \quad (8)$$

This is the equation to the stream lines followed by a perfect fluid streaming past a stationary cylinder. Any one can be mapped out by taking some numeral value for ψ_1, and finding from equation (8) values of r and θ which agree with this. The result of such an operation is represented in Fig. 8, reproduced from a paper contributed by Major A. R. Low to the Proceedings of the International Air Conference held in London last June. It represents the stream lines round a cylinder immersed in a perfect fluid.

If the cylinder is in rotation we may regard its surface as one of the stream lines of a Rankine free circular vortex, as already explained in the earlier part of this article. The motion of the fluid is then found by adding the velocities due to this vortex to the velocities corresponding to the stream lines in Fig. 8. As already mentioned, potentials are additive, and since a stream line function (otherwise known as Stoke's current function) can also represent a potential we can get the stream lines due to a combination of two or more systems of flow by simply adding together the functions corresponding to the two cases taken separately.*

Hence to solve completely the problem we are considering we have to add to ψ_1 as found above,

* Mathematicians tell us that the order in which a differentiation is effected is not always a matter of indifference and at the singular points of some surfaces $\frac{\partial^2 \phi}{\partial x \partial y} = -\frac{\partial^2 \phi}{\partial y \partial x}$. This, however, is merely a mathematical curiosity and in all cases of practical importance, however, $\frac{\partial^2 \phi}{\partial x \partial y} = \frac{\partial^2 \phi}{\partial y \partial x}$.

† The transformation of Laplace's equation from rectangular to polar co-ordinates is too lengthy for reproduction here. It will be found in any good book on the calculus.

* There are certain restrictions to this proposition, which need not be discussed here.

the stream line function ψ_2 corresponding to the vortex which we have represented by the rotating cylinder. In this case the stream lines are everywhere circles, and the velocity along any one is given by $-\frac{a\,t_0}{r}$, where t_0 denotes the surface speed of the rotating cylinder.

If we differentiate ψ_2 along r we get the tangential velocity, so that

$$\frac{\partial\,\psi_2}{\partial\,r} = -\frac{a\,t_0}{r}$$

so that

$$\psi_2 = -\,a\,t_0 \log \frac{r}{a},$$

the constant of integration being chosen so as to make ψ_2 zero at the surface of the cylinder or in other words stream line No. 0 is represented by this surface.

Fig. 8.

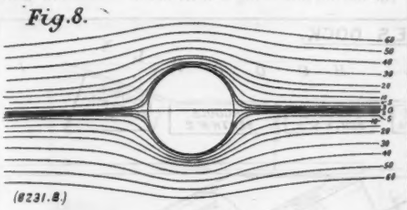


Fig. 9.

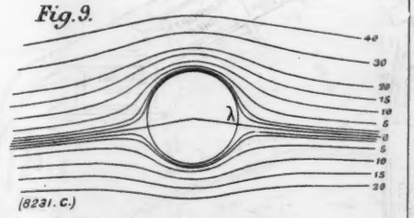
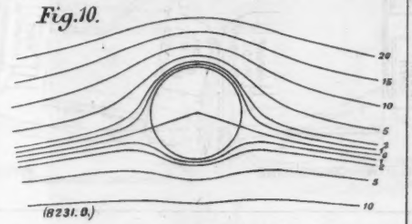


Fig. 10.



The combined stream line function for the two types of flow is :

$$\psi = \psi_1 + \psi_2 = -\,\mathrm{V}\left(r - \frac{a^2}{r}\right)\sin\theta - a\,t_0 \log \frac{r}{a}.$$

Figs. 9 and 10 also taken from Major Low's paper, show these stream lines for different ratios of t_0 to V.

In actual practice this expression only holds at a considerable distance from a rotating cylinder fixed in an air current. The lines of flow do not follow the surface of the cylinder completely round, but break away, leaving a dead water space. With a good stream line form, however, such as a normal wing section, the stream lines appear to hug the surface very nearly as they would in the ideal case of a perfect fluid. Any surface whatever may (in theory at least) be a stream line since the latter can also be considered as a equipotential line, and every conductor becomes an equipotential surface if charged with electricity. Hence corresponding to every wing form there is some stream line function, which includes the contour of this wing as a possible value. The problem of discovering this analytically presents very great difficulty, but there are certain graphic methods by which the circle shown in Figs. 9 and 10, can be transformed into a wing form, and the stream lines in the figure into stream lines corresponding to the wing section.

(To be continued.)

BUILDING IN EARTHQUAKE COUNTRIES.

By W. H. THORPE, Assoc.M.Inst.C.E.

THE problem of building in earthquake countries has for years past received considerable attention, particularly in Japan, where much ability has been displayed in an endeavour to surmount the difficulties involved. The demand for buildings of magnitude compelled attention to the study and resulted in a statement of requirements with respect to such buildings, which have influenced design of the more recent structures. The precautions adopted appear to have been sufficient in the case of minor earthquakes, but in a very large measure ineffective in the terrible experience of a few months since.

In the case of steel-framed buildings an attempt has been made by *force majeure* to limit the destructive effects by proportioning the steel framing with large reserves of strength, particularly in the matter of what would commonly be called wind bracing, this being made to resist forces many times greater than that of the wind proper, and care being taken to ensure a true continuity in the make-up of the stanchions—even so, it was not expected that screen walls or partitions would be immune from damage.

Notwithstanding the more or less favourable accounts given with respect to the behaviour of some of the more recent structures in steel, or in reinforced concrete, it is clear from the statements of unbiassed eye-witnesses that not one of these escaped damage—generally serious, or with complete collapse. An entirely new treatment of the problem would seem to be necessary. This may be found in the fundamental principle that the building should be so supported as to be unaffected by horizontal earth movements, which may be secured by so supporting the structure that it does not of necessity move as the earth moves, to be achieved by suspending the building by tension rods from stable steel frames by suspension—in the case of light structures—from flexible steel uprights, or by support upon balls of cast-iron, steel, or granite.

The last-named method, though not new to the writer, has recently been proposed by Professor Bailey Willis, of Stanford University (U.S.A.) Horizontal movement of the earth's surface would not then disturb the building which by virtue of its mass would remain still. The measurement of earth tremors is now, by some instruments, effected by application of the same law of inertia. A sound principle in structural design is that sudden displacements, involving the development of force, should either be adequately met by strength provided, or accepted by yielding that is harmless. The arrangement proposed would seem to meet the last-named condition in great measure, but the writer does not yet see any practicable method of dealing with the greatly less destructive vertical movements. In the Nino-Pwari earthquake of 1891 a 9 in. horizontal range was observed, while at Tokio in 1894, though the range was but 3 in., the rate of acceleration was 3 ft. per sec. per sec. Generally the range is quite small, and acceleration seldom greater than 2 in. per sec. per sec.

Structures on western lines are wholly unsuited to earthquake countries, as is demonstrated by the recent experiences in Tokio and Yokohama. From records available it would appear on the authority of an American technical journal that 7 in. of horizontal movement was experienced, though unofficial statements, probably from persons not used to precise observation, indicate movements greater than this. Clearly earthquake shock and disturbance may, in extreme cases, be such that nothing will stand, but there is good reason to expect that if not much greater than that recently observed at Tokio, the conditions may be met.

Dealing with the first-named method, the problem of suspension of a building to yield the advantages aimed at becomes a question of structural design simply. If, for instance, an office building 160 ft. by 80 ft. by 60 ft. high, having an internal well of 80 ft. by 20 ft., were carried by a steel girder platform, not resting on the ground, but suspended at 12 points, each point of suspension would be required to take approximately 450 tons, that is to say, four suspension rods of 4 in. diameter, or 16 rods of 2 in. diameter at each such point, would carry the load at 9 tons per square inch. The upper ends of the suspension rods—say, 20 ft. long—would be carried by wide based steel towers, generally, though not of necessity, housed within the building. The towers themselves would be well founded, and the only part of the structure required to move with earth movement. The weight of steel in the grillage platform and supporting towers would probably be more than one-half, but less than the total weight of steel in an ordinary framed building. The enhancement of total cost would be, perhaps, 20 per cent. as compared with that of an ordinary building to meet ordinary requirements, and no greater than for steel-framed buildings constructed of specially heavy steel work in a vain attempt to control the uncontrollable.

The second method named, by which a comparatively light building would be carried by attachment at the top to columns capable of a moderate side flexure without hurt, would have but limited application, while the third proposal, support upon balls, themselves resting upon a concrete base, would probably be best suited to reinforced concrete structures.

It is only in comparatively recent years that really heavy buildings have been attempted in Japan. Native modes of construction, based on age-long experience, have favoured light and elastic framings, with enclosing screens, an intelligent appreciation of scientific fact, though perhaps not fully understood.

THE EXTENSION OF THE PORT OF CALCUTTA.

TILL recently the accommodation of the Port of Calcutta consisted mainly of what are known as the Calcutta jetties, just south of the Howrah Bridge across the Hooghly, and the Kidderpore Docks which were first brought into use in 1892 and subsequently extended, until they now provide altogether some 27 berths suitable for vessels drawing up to 30 ft. of water. The Calcutta jetties are nine in number, and deal with most of the import trade. The Kidderpore Docks deal mainly with export business and coaling, 10 of the berths there being devoted to the latter trade.

For many years it has been apparent that steps would have to be taken to make the accommodation more commensurate with the business of the port. As long ago as 1913 a report was presented by a Government committee recommending the immediate construction of a number of additional river-side berths with a view to develop as rapidly as possible the available accommodation pending the completion of the main part of their programme, which proposed a large and deep dock in the neighbourhood of Garden Reach, about 4 miles below the Howrah Bridge, and a mile or so below the entrance to the Kidderpore Docks. The site proposed was already owned by the Port Commissioners, and the programme was embarked upon. The war, however, put a stop to anything in the way of rapid progress, but since its termination work has been pushed on and all the riverside berths which were undertaken have now, we understand, been brought into use, while material progress is being made with the large dock which formed the chief item of the scheme.

Before dealing with the latter we may give a few particulars relative to the new Riverside berths at Garden Reach. These are five in number, four being produce berths and the fifth a coaling jetty. The location of these berths is shown in the small scale map in Fig. 1, page 38, and also in the larger plan, Fig. 2. The produce berths are reinforced concrete and steel structures, provided with large double-storied transit sheds. The river at this point has a tidal range of 20 ft., but the bed has been dredged to allow 40 ft. of water at the berths at low water. The slope of the bank is run back from the deep water at 2 : 1, resulting in a width of about 132 ft. of quay and building standing out over the water. The quay provides a width of deck of 30 ft. on the river side of the sheds, while the latter measure about 172 ft. from back to front exclusive of a loading platform on the shore side. The upper storey has a width of 157 ft. back to front. Mass concrete foundations of large area support these sheds so far as the portion away from the water's edge is concerned. The loads near the top of the slope of the bank are supported on groups of reinforced concrete piles, while those further out directly over the water are carried on screw piles in groups of from two to four. The sheds are steel structures with walls of reinforced concrete. On the wharf frontage semi-portal electric cranes are provided and cranes are also arranged at the back of the

buildings commanding both storeys. There are also lifts between the floors inside the sheds.

As already stated, although these new berths should greatly assist in expediting the despatch of traffic at the port, the main feature of the programme of extension adopted in 1913 was the proposal for a new dock, now named the King George's Dock. The proposal as finally settled is shown in the small scale map, Fig. 1. It comprises a dock with a turning basin and two long arms, the wharfage being provided with the necessary sheds, and the dock communicating with the river by way of two locks. The whole scheme will provide a water area of 190 acres, with 35 berths and total quayage of 25,000 ft. The general lay out is roughly north and south. The locks lie at an angle of about 150 deg. to the direction of the river and face down stream. The turning basin in the dock leaves an area of 800 ft. by about 1,200 ft. clear for manœuvring. The two arms of the dock have a width of 650 ft., and they will ultimately extend to a length of about 4,500 ft. There is no suggestion of proceeding at present with this project in full, the idea being to get a section of it into use as early as possible and to continue to expand the accommodation by degrees subsequently. The plan given in Fig. 2 shows the work which is now being undertaken which will be carried at first as far as the first bund shown. A second stage will take matters as far as the commencement of the two arms of the dock. The first stage therefore is chiefly concerned with the turning basin and the locks. The locks consist of one lock proper, and one through dry dock. The former is 90 ft. in width and of 700 ft. usable length. The dry dock alongside has a total length of 1,190 ft. and is divided into two by means of a floating caisson, the two sections providing lengths of 575 ft. and 590 ft. respectively, and the width being 80 ft. The design adopted will make it possible for ships to enter the dry dock from either end, while the dry dock could also be utilised as an alternative entrance to the wet dock. The sill of the entrance lock will be at — 30, the datum line being 2·5 ft. below lowest low water level. At low water therefore the depth of water on the sill will be 32 ft. 6 in., and at high water 52 ft. 6 in. The wet dock is to be maintained at a level of + 15, the bottom being cleared to — 21, giving a depth of water of 36 ft., with a depth in the lock corresponding with this level of + 15, of

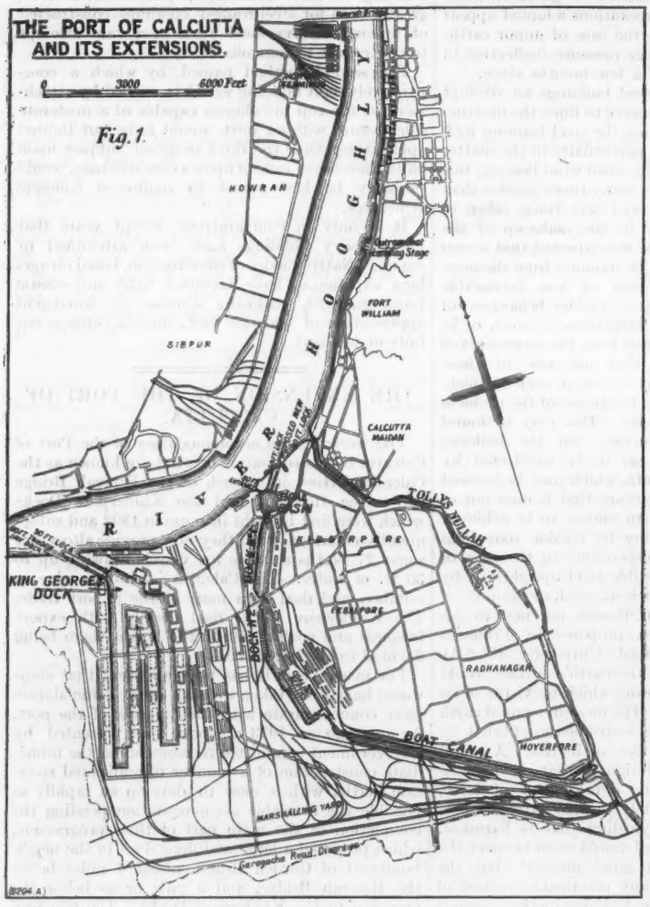


Fig. 1.

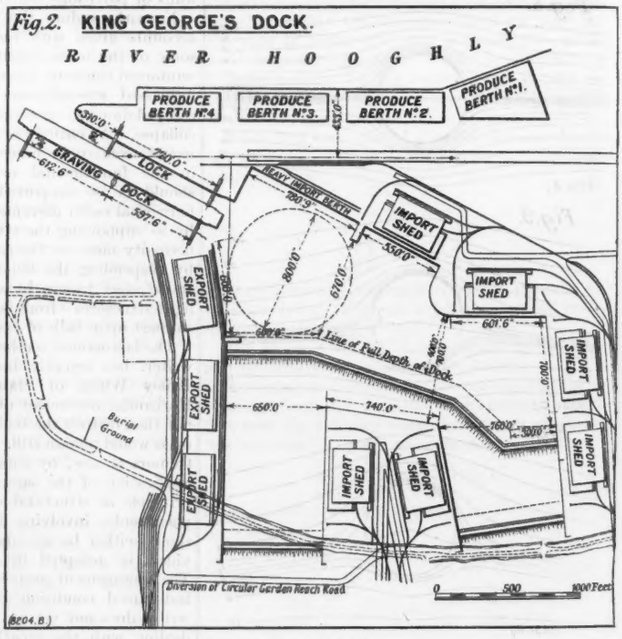


Fig. 2. KING GEORGE'S DOCK.

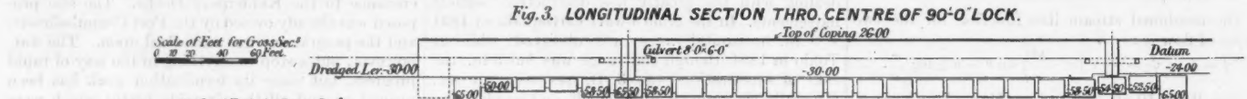


Fig. 3. LONGITUDINAL SECTION THRO. CENTRE OF 90'-0" LOCK.

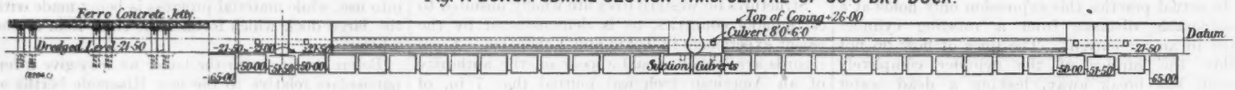


Fig. 4. LONGITUDINAL SECTION THRO. CENTRE OF 80'-0" DRY DOCK.

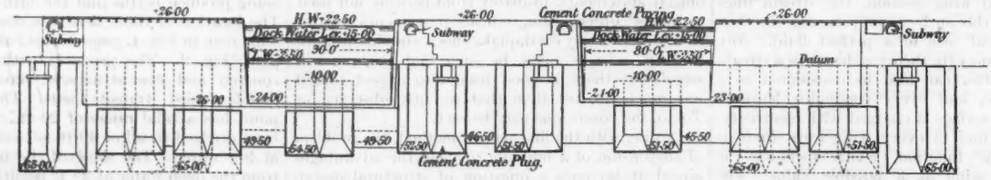


Fig. 5. CROSS SECTION THRO. INNER CAISSON RECESSES

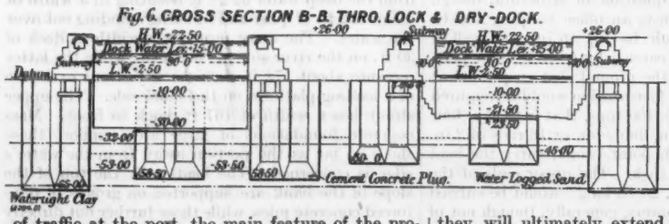


Fig. 6. CROSS SECTION B-B. THRO. LOCK & DRY-DOCK.

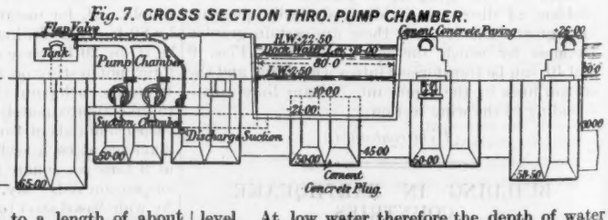


Fig. 7. CROSS SECTION THRO. PUMP CHAMBER.

45 ft. The dry dock floor is being placed at — 21·5, giving a depth of water at lowest low water level of 24 ft., with 36 ft. 6 in. at normal wet dock level and 44 ft. at high water level.

The water level of + 15 has been adopted for the wet dock with a view to limiting the loss of water by leakage. Pumping plant will be installed to maintain this level though it will be clear that if lockages are arranged at suitable times the work the pumps are called upon to perform should be comparatively light. The water for the pumps will be drawn from the Hooghly, and it is intended to make the installation of a capacity sufficient to supply the Kidderpore Docks as well, with a view to closing the present source of supply from Tollys Nullah. The lower level of the new dock should obviate a large amount of dredging, as water need not be admitted at times of high flood when the river carries a heavy proportion of silt.

The new wet dock when completed will provide berths for about 35 vessels over 550 ft. in length. It is proposed to use one side of the dock for imports and the other for export traffic. In the first instalment the shedding will consist of three import sheds, and one export shed, while one berth will be devoted to heavy lifts. The import sheds will have three storeys, will be served by 3-ton semi-portal cranes on the wharf, and will be provided inside with 3-ton lifts. The wharf cranes will command the wharf deck and also a platform level with the first floor of the shed. The export sheds, of which only one is to be built at first, will be of two storeys with an open first floor platform on the quayside served by semi-portal cranes. The site presented some difficulties owing to the fact that to the west of the area there lies a large cemetery which cannot be encroached upon, while the peculiar projection in the north wall of the dock is accounted for by the presence of a building which had to be allowed to remain intact, in order not to offend native religious feeling. Actually in this case, although the free water area is somewhat curtailed by the irregularity the stretch of straight is long enough to accommodate large-sized steamers.

Owing to the difference in water levels it has been decided to adopt sliding caissons, electrically operated, instead of sets of double gates for the lock and dry dock. The positions of these are indicated in Fig. 2. The river approach is to be protected; originally it was planned that the approach works should take the form of reinforced concrete jetties, but this has been modified to monolith construction, which, according to programme should be put in hand in January, 1924.

As is well known, the whole of the Calcutta area forms part of the Ganges Delta and the alluvial soil, of recent deposit, is not suited to heavy loading. As is usual with this type of ground in the vicinity of water it is very treacherous, a fact which was amply demonstrated during the construction of the Kidderpore Docks. The site of the new docks shows sand and silt overlaying a bed of stiff clay at a level varying at different points, but somewhere about — 63. As a result of careful study of these unfavourable conditions it was decided to adopt for the walls, &c., a monolith type of sectional construction, each section being sunk independently till the outer ones rest on the stratum of stiff clay. The remainder will be sunk to about — 52 or so as indications show to be necessary. The work now in hand consists for the most part in the preliminary construction of the lock and dry dock, but the walls of the section of the wet dock to be first brought into use are also being taken in hand on the same lines. The drawings, Figs. 3 to 7, page 38, show in outline the construction adopted for the dry dock and lock. In the first instance large monoliths, 40 ft. by 40 ft., are being sunk spaced 5 ft. apart to form the foundations of the main walls. These monoliths will be finished at datum level, being carried down as far as necessary to enter the clay referred to above. The monoliths are set back slightly from the wall face, and the wall is finished to proper dimensions by means of brick facing. Above the datum line gravity walls are carried up to + 26, the construction being stepped at the back as shown in the sections, Figs. 5, 6 and 7. When the monoliths have been sunk to final level the spaces between them will be sealed by means of piles, excavated to a convenient depth and then filled with brick or concrete as determined later.

Both the lock and dry dock will have floors down which run a row of similar but smaller monoliths, 36 ft. by 36 ft., as shown in Figs. 6 and 7. These will be sunk as deep as required and the intervening spaces will be treated as in the case of the wall monoliths. The remaining floor space will be excavated and filled with brick work built *in situ*, the facing wall for the sides being carried up from this to datum level, and, in the case of the dry dock, stepped as shown in Fig. 6, &c. At about datum level, culverts, 6 ft. by 8 ft., will be built in the interior of the wall monoliths for use in connection with pumping and equalising, while further tunnels will be provided in the upper part of the gravity section wall built upon the monolith foundation.

These points will be clear from Figs. 3 to 7, of which Fig. 4 is a longitudinal section of the dry dock, while Fig. 3 gives a longitudinal section of the entrance lock. The cross-section Fig. 5 shows to the left a section through the lock at the inner sliding caisson recess, and on the right a section at the corresponding recess of the dry-dock. At these points the large monoliths are set back and the recess floor is provided with small monoliths of the type used in the centre of the lock and dock floors. A normal cross-section through both lock and dock is shown in Fig. 6, and illustrates the several features referred to above. Fig. 7 is a cross-section through the pump chamber of the dry dock, situated at the point where the floating caisson is placed as shown in Fig. 4, and connected with each portion of the dry dock by short suction culverts. Fig. 4, it may be remarked shows the original design of approach jetty, since modified.

The method of sinking the large monoliths is well illustrated in the views reproduced in Figs. 8 to 12 on the present page and Plate II. It is the common one, familiar to all engineers and especially to those acquainted with works in India. The base of each monolith consists of a well curb made of steel plating arranged with the outside walls vertical, but with the inner sloped so as to form a cutting edge. Some of the curbs in course

FIG. 8. GENERAL VIEW OF THE AREA EXCAVATED FOR THE ENTRANCE WORKS.

of assembly on the site are shown in Fig. 9. The well curbs have in some cases been ordered from this country; others were manufactured in India. The curbs are 5 ft. deep and weigh about 27 tons. They are filled with concrete, and reinforced concrete walls, 6 ft. thick, are raised on them to a height of another 5 ft. The remainder of the monolith is built of brick as the process of sinking is carried out. The lower portion is brick in cement, the upper brick in lime-mortar. Vertical and horizontal bonding rods and bars are carried through the work as shown in Fig. 11. The wells are sunk by excavating the material through the four shafts, 11 ft. square, left in the interior. Loading is adopted if the monoliths will not sink of their own accord as the material is removed from the interior. When at final level the curb is plugged inside with concrete and the shafts filled in. Different stages are illustrated in the views reproduced in the views on page 39, and on Plate II.

The present programme of the work, including the five berths referred to above, is designed to be completed by 1927, though the erection of sheds and reclamation will probably extend into the early months of that year. The monoliths for the entrance works are expected to be complete by September, 1925, but for the wet dock the work will continue on into 1926. The amount of well sinking to be done to complete the first section is about 10,250 ft., on 210 monoliths, and the work completed to date shows that progress has been accelerated slightly above that provided for by the programme. A recent progress report shows that about 5,669 ft. of wells have been built and 5,000 ft. sunk, about 45 monoliths being completed and sunk to datum level. The actual rate at which sinking has been carried out works out at 254 lineal ft. per month, as compared with the 224 ft. anticipated by the programme. The end of July last, as regards the entrance works, showed 53 per cent. of the concrete work in the monoliths completed and 54·5 per cent. of the brickwork of the wells finished, while 92·5 per cent. of the open excavation had also been accomplished.

As stated, the monoliths of the wet dock walls are similar but somewhat smaller (36 ft. by 36 ft.). A start was made with these in January, 1923, but this work will be more rapidly pushed on as sinking plant is released from the entrance works.

With regard to the cost the estimates finally passed in 1921 for the entrance and dry docks were Rs. 481,86,560, and for the first instalment of berths Rs. 282,08,560. Actual costs till July, 1923, had shown some divergence from the estimates, increases in some cases, but economies in others, on the whole the cost having shown a reduction of about 10 per cent. The cost of open excavation per 1,000 cub. ft. had worked out at Rs. 24, but for excavation in the well shafts had been Rs. 76, which compared with the Rs. 40 estimated. On the other hand the well curbs estimated at Rs. 23,700 each had worked out at Rs. 18,000; cement brickwork had cost Rs. 89 for 100 cub. ft. compared with Rs. 96 estimated, but lime brickwork had worked out at Rs. 51, compared with the estimate of Rs. 40. Some economy had been realised in cement concrete which was originally estimated at Rs. 148 per 100 cub. ft. and had been laid at a cost of Rs. 139. It is estimated that the whole of the masonry of the lock and dry dock will show a saving of Rs. 29,00,000 on the estimates, but this will be partially off-set by additional expense of Rs. 3,81,600 on the well sinking.

The work has involved opening up and organising new brickfields, the requirements of the work running to about 53,000,000 bricks per annum. Brickfields have been laid out on land reclaimed with the earth excavated from the entrance works, &c., 6½ miles of railway track laid down and 104,000,000 bricks used in building kilns. Suitable material for the bricks was found in an outlying district of the Commission's area. The regular progress of the work is dependent upon the transport daily of 2,400,000 bricks, 61,000 cub. ft. of earth, 4,500 cub. ft. of mortar and 70 trucks of miscellaneous stores. Hand excavation has proved satisfactory but cranes have also been used especially in the sinking of the monoliths. For this work twelve 4-ton and two 3-ton cranes are in use with grabs and skips, and four 30-cwt. cranes are to be employed in excavating the spaces between the monoliths.

The work is being done departmentally by the Commission, which came to the conclusion that the abnormal conditions prevalent after the war were unfavourable to making good contracts. The bulk of the work is carried out on the petty contract system, the Commissioners supplying nearly all materials. This system, while it avoids the main contractor's profit, involves more technical supervision as the contractors provide the labour only. Supervision was a little difficult to arrange on the scale necessary, as the Commission's normal staff was quite inadequate to deal with so large an undertaking. In making the appointments requisite for carrying on the work on the lines indicated above it was difficult to secure experience combined with a knowledge of Indian conditions. At the same time it was found necessary to institute a new grade of probationary assistant engineers to expand the number of junior supervisors, and these were on appointment largely lacking in experience. This difficulty is now in way of being overcome, and the Commission is satisfied that the undertaking is proceeding satisfactorily and on economical lines.

We are indebted to the Port Commissioners of Calcutta for the above information regarding the progress of this important work, which is being carried out under the direction of Mr. J. MacGlashan, M.Inst.C.E., chief engineer. Mr. J. Angus, M.Inst.C.E. of 10, Princes-street, Westminster, to whom we are also indebted for assistance in the preparation of this article, is the Commissioners' consulting engineer in this country.

THE INTENSITY OF RAINFALL.

The Intensity of Rainfall and Consequent Run-off from a Catchment; a Suggestion.

By J. W. MEARES, C.I.E., M.Inst.C.E., late Chief Engineer, Hydro-Electric Survey of India.

THIS brief paper does not pretend to discuss the knotty problem of flow-off or run-off, but is merely a sign-post suggesting a line of advance. By run-off here is meant the total amount (or percentage, generally) of the rainfall over any given period which reaches the measuring point—weir, dam, &c.—at the lowest point of the catchment area considered. (The maximum flood run-off due to any particular run of precipitation is not dealt with, though it is equally important and equally resistant to solution.) Generally speaking, from the point of view of water storage, it is the annual run-off which matters most; and, as between different years, it is the year of lowest run-off which is most vital.

The discharge of many rivers, whose catchment areas and rainfall are known, has been measured and recorded; so also has the inflow into many reservoirs and tanks, great and small, where these data were also available. Mr. R. B. Buckley, C.S.I., has recorded 22 pages of such data, relating to all parts of the world, in a book* carried by most irrigation engineers. The net result of all these observations is that data from one catchment afford some guide to what will happen in the neighbourhood; but that a method of estimation employed in one country is of little use in another, or even at any considerable distance in the same country.

The factors involved are broadly:—

(i) The nature of the catchment.
(ii) The rainfall and climate.

The size of the catchment will always be known; its shape will generally be of vital importance to the flood run-off and may to an uncertain extent affect the total run-off. The steepness of the ground, the nature of the surface and the sub-soil, and the amount of natural vegetation and of cultivation are the main determining factors. All these will also be known. In small areas it will be possible at once to classify the catchment as bad, average or good for run-off, or as intermediate between one or another pair. In larger areas, consisting of several types of ground it is usually not difficult to place the whole in one grouping or another. It is fairly safe to assume that if the conditions of rainfall could be reproduced in several catchments, classified as similar in size and general character, even in different continents, the run-off would not differ very materially. The discrepancies arise, in fact, mainly from the incidence of the rainfall, though prevailing winds, temperature and humidity are additional factors.

The rainfall over a comparatively flat catchment of moderate size will in general be more or less uniform; but where there are hills the variations in different parts, even of a small catchment, may be great. It is therefore necessary to have enough rain gauges to give a fair average. It is almost universal amongst meteorologists to record the rainfall once every 24 hours, generally at 8 a.m. This is an admirable way for obtaining statistical tables, but is most misleading in other ways, as the recorded falls of two successive days will often in reality be due to one downpour just before and after the hour of reading. The records show the daily precipitation in inches; occasionally there is a recorder also, from which the time of the occurrence and some idea of the intensity may be obtained, but these are seldom found in the places where they would be of use to the engineer.

Now this last factor, the intensity of the falls, is in all probability the most important one; and hitherto it has never been taken into account. It has been my privilege recently to describe a very simple and inexpensive gauge* that will fractionate the rainfall into any desired number of intensities; and as I have not patented the device I make no excuse for putting it forward. With this instrument the daily readings would be tabulated according to the rates per hour at which different amounts fall. It is a matter for field work to determine what limits of intensity are important. I have recorded falls at the rate of 8 in. and even 10 in. per hour for short periods; but it seems likely that all falls at the rate of more than 2 in. or 3 in. an hour would be equivalent in the matter of run-off, at least in moderate-sized catchments. Probably also all falls below 1 in. an hour could be lumped together as "light falls," though falls at this rate extending over a day or several days, such as I have experienced in Bengal, might upset all calculation. Long continued falls must be taken into consideration as such.

Another matter of importance in relation to rainfall is the sequence of falls. No account is ordinarily taken of this, as the labour of tabulating daily results is disliked. As I shall show, it is not really a lengthy business. Clearly a fall of 6 in. of rain spread evenly over 24 hours will only give a fraction of the run-off of the same amount falling in 6 hours, but also the run-off in both cases will be greatly affected by previous light falls that may have been completely absorbed. And light falls following heavy rain may run off when otherwise they would have been entirely lost, especially on steep or rocky catchments.

I turn now to India, where it is no exaggeration to say that the life of the people depends largely on the run-off of the very variable rainfall; for irrigation from rivers and reservoirs is the lifeblood of the country. Here, in particular districts, empirical methods of estimating total run-off simply as a percentage of the rainfall are found valuable; for example, Strange's curves in Bombay.† So long, however, as intensity and daily incidence of the rainfall are not taken into account there must be very great uncertainty. Thus, to take actual examples given by Buckley,‡ 4·1 in. of rain in nine days in one year gave a reservoir the same quantity of water as 27·8 in. in 114 days in another year; while 5·2 in. in eight days of one year produced the same total run-off into another reservoir as 23·2 in. in 122 days of another year—these being the total falls in a dry part of Bombay.

The late Mr. G. T. Barlow, C.I.E., the first chief engineer of the Hydro-Electric Survey of India, was a well-known authority on these questions and on irrigation generally in his own district—the United Provinces. He carried out a certain amount

* "The Irrigation Pocket Book," pages 324 to 346. E. and F. N. Spon.

* "The Experimental Development of an Automatic Integrating 'Intensity' Rain-Gauge without Clockwork," Institution of Civil Engineers, Selected Engineering Papers, No. 2; 1923. (Telford Premium.)
† "Irrigation Pocket Book," page 326.
‡ *Op. cit.*, page 327.

of experimental work, and from it devised a novel method of determining run-off; it is this that I wish to put forward. Mr. Barlow's untimely death occurred before he had reached any approach to finality, but I believe his ideas have the elements of a valuable advance in forecasting annual run-off. His investigation was confined to one district, but could easily be applied elsewhere; unfortunately, no other engineer has taken sufficient interest in the matter to follow it up.

TABLE I.—*Barlow's Suggested Method of Determining Total Run-off.*

Classification of Catchments.

Type A.	Flat, cultivated absorbent soils.
Type B.	Flat, partly cultivated stiff soils.
Type C.	Average catchment.
Type D.	Hills and plains with little cultivation.
Type E.	Very hilly, steep and rocky, with little or no cultivation.

Classification of Rainfall (Sub-Tropical).

Neglect.—All falls under ½ in. a day unless continuous for several days; also falls from ½ in. to 1 in. a day if there has been no rain immediately before and none follows.

Light Falls.—(*a*) All falls mentioned above when in continuation of, or followed by, similar (or heavier) falls as mentioned; (*b*) also steady falls from 1 in. to 1½ in. a day when not preceded or followed by similar or greater amounts.

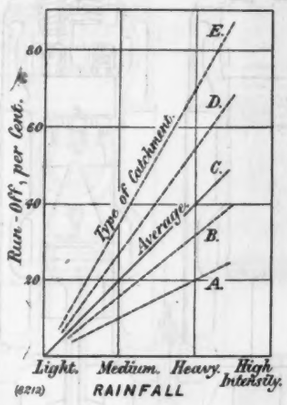
Medium Falls.—(*a*) Falls from 1 in. to 1½ in. a day when preceded or followed by any but light falls; (*b*) also all falls from 1½ in. to 3 in. a day.

Heavy Falls.—(*a*) All over 3 in. a day or continuous falls at a rate over 2 in. a day; (*b*) also all falls of an intensity of 2 in. per hour or more.

Barlow's Coefficients; Per Cent of Rain Flowing Off.

Type of Fall	Catchment. A.	B.	C.	D.	E.
Light	1	3	5	10	15
Medium	10	15	20	25	33
Heavy	20	33	40	55	70

Briefly, Barlow divided all catchment areas into five classes; an "average catchment," leading on the one hand through a transitional stage to an extremely steep and bare rocky area and on the other through another transition to flat and highly-cultivated absorbent land. He also classified daily falls of rain into "light," "medium" or "heavy" as well as could be done on plain daily gauge readings, with a caution as to including known falls of high intensity (over 2 in. per hour) as "heavy" regardless of their amount. Then by means of percentages for each of the 15 possible cases he endeavoured to ascertain the total run-off day by day. The actual classification he adopted is shown in the table above, but it is doubtful if the figures are of much value. To test the method, a number of clearly defined catchments must be taken where the actual run-off can be measured, and fractionating rain gauges must be installed in them and read daily. In this way it seems likely that percentages could be obtained agreeing fairly well with actuals. No doubt the percentages would be different in temperate countries of small rainfall and in sub-tropical areas of heavy and intense precipitation; but that is immaterial, as the results would be used in their country of origin. The constants might well be found to differ for large and small catchments, and meteorological conditions must always lead to some uncertainty.



Mr. Barlow settled upon these coefficients after trial and error in a large number of catchments of various sizes—mostly under 50 sq. miles, including some quite small ones—feeding tanks—where in every case the actual run-off was known. He claimed that in the case of new works he could forecast with fair accuracy in the same province. But he told me that, if he could obtain records of the intensity of all heavy falls, he could certainly carry the matter further. This led up to the experimental work I have already mentioned, and to a satisfactory solution of the problem of fractionating rainfall. Clearly the percentages ought to be on a curve for each type of catchment, from which an intelligent clerk would be able at once to mark off the appropriate figure for any fall. Also the percentages in the case of "heavy" falls should be higher when specially great intensities are recorded. I have tried this to see how it affects an example, as Barlow's results are almost certainly too low. In the absence of any data on which to give actual workings I am driven to concocting a supposititious table of a month's rainfall, bringing in all classes of precipitation and with dry days interspersed to enable the working of Barlow's method to be shown. The run-off is calculated for three of the five types of catchment, namely, the extremely flat type A, an average catchment C and a medium good catchment D. The extremely steep and rocky type E is abnormal and does not lend itself to comparison. The sign * after the figures in Table II indicates that they are probably below the mark.

The mean run-off over the whole period (one month) shown in this table, with the tropical type of precipitation assumed, comes to 12 per cent. of the total rainfall, in the worst catchment, 24 per cent. in an average catchment and 33 per cent. in the intermediate good catchment. (In the E type it comes to 43 per cent. of the total, which would certainly be far below the mark for some hill areas I know). Bearing in mind that the method was evolved in the United Provinces the results (for an average catchment) may be compared with the average total run-off of the catchment of the Ganges above Benares, embracing the whole Province; this is given by Buckley* as averaging 35 per cent.

For the whole peninsular (*i.e.*, excluding the area to the East of Bengal) the same authority gives the average total run-off as 41 per cent.; while in the table from which this figure is taken there is not a single river with an average run-off as low as 24 per cent.† Probably the approximate run-off year by year, which would be more useful, exists among the irrigation records in India.

Strange's curves, as generally used by irrigation officers in Bombay, cannot properly be compared with the above as they deal with annual rainfall, but for a year's monsoon in which one month gave nearly 30 in. Strange's run-off would also be very much higher on all his three classes of catchment.‡

By way of experiment I have retabulated the hypothetical month, on the basis of an average catchment, after an attempt at modifying the constants, as they would be modified if rainfall intensity were recorded. Using Mr. Barlow's 20 per cent. and 40 per cent. for medium and heavy rainfall, the curve shows this straight line extended to zero (instead of 5) and on to 60 for great intensities.

Then in tabulating, I have moved along the curve where previous or subsequent rain, or heavy intensities, seem to show it to be correct to do so. (It is obvious of course that an extra fraction of an inch of fall cannot suddenly increase the run-off from 5 per cent. to 20 per cent.)

TABLE II.—EXAMPLE OF ANALYSIS OF DAILY PRECIPITATION BY BARLOW'S METHOD.

Date.	Daily Rainfall at Intensities of: Under 2 In. per Hour.	2 In. per Hour Upwards.	Class of Fall in Preceding Table.	Catchment, Type A. Barlow's Run-off. Per Cent.	Inches.	Catchment, Type C. Barlow's Run-off. Per Cent.	Inches.	Catchment, Type D. Barlow's Run-off. Per Cent.	Inches.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	0·50	—	Neglect	—	—	—	—	—	—
2	—	—	—	—	—	—	—	—	—
3	0·75	—	Neglect	—	—	—	—	—	—
4	—	—	—	—	—	—	—	—	—
5	0·40	—	Light (*a*)	1	0·03*	5	0·02	10	0·04
6	0·40	—	Light (*a*)	1		5	0·02	10	0·04
7	0·80	—	Light (*a*)	1*		5*	0·04*	10*	0·08
8	1·20	—	Light (*b*)	1*		5*	0·06*	10*	0·12
9	—	—	—	—	—	—	—	—	—
10	—	—	—	—	—	—	—	—	—
11	1·25	—	Medium (*a*) ..	10	0·12	20	0·25	25	0·31
12	2·50	—	Medium (*b*) ..	10*	0·25*	20*	0·50*	25*	0·62
13	1·00	0·50	Medium and heavy	10 and 20*	0·20*	20 and 40*	0·40*	25 and 55	0·52
14	—	—	—	—	—	—	—	—	—
15	—	—	—	—	—	—	—	—	—
16	3·00	1·00	Heavy	20	0·80	40	1·60	55	2·20
17	2·00	—	Heavy	20*	0·40*	40*	0·80*	55*	1·10
18	0·50	—	Medium	10	0·05	20	0·10	25	0·12
19	—	—	—	—	—	—	—	—	—
20	—	—	—	—	—	—	→	—	→
21	0·20	0·50	Light and heavy ..	1 and 20	0·10	5 and 40	0·21	10 and 55	0·29
22	—	—	—	—	—	—	—	—	—
23	3·00	—	Medium	10*	0·30*	20*	0·60*	25*	0·75
24	—	—	—	—	—	—	—	—	—
25	1·00	0·25	Light and heavy	1 and 20	0·06	5 and 40	0·15	10 and 55	0·23
26	0·20	—	Light	1	—	5	0·01	10	0·02
27	1·25	0·10	Medium and heavy	10 and 20	0·14	20 and 40	0·29	25 and 55	0·36
28	2·50	—	Medium	10*	0·25*	20*	0·50*	25*	0·62
29	0·20	—	Light	1*	—	5*	0·01*	10*	0·02
30	1·00	2·50	Heavy	20*	0·70*	40*	1·40*	55*	1·92
	23·65	4·85							
Total	28·50				3·40		6·96		9·36
Mean percentages			.. ..	12		24		33	

* This sign indicates that a higher percentage and amount would probably be nearer the mark.

TABLE III.—*Modified Analysis of the Example in Table II for Average Catchment.* (*Dry Days Omitted.*)

Date.	Per Cent.	Run-off.
5	5	0·02
6	5	0·02
7	10	0·08
8	15	0·18
11	20	0·25
12	30	0·75
13	40 and 50	0·65
16	50 and 60	2·10
17	50	1·00
21	5 and 40	0·21
23	30	0·90
25	10 and 50	0·22
26	10	0·02
27	30 and 50	0·42
28	30	0·75
29	10	0·02
30	40 and 50	1·65
		9·24

Average 32 per cent.

Omitting the dry days, Table III shows the percentages taken and the consequent run-off, averaging 33 per cent. instead of 24 per cent. Although this is, and is intended to be, a "cooked" result, it is almost certainly nearer the mark than the first tabulation. It will be seen that the labour involved is very small, and will be no greater with genuine data to work on. What is now required is that the curves should be rectified to agree with actuals.

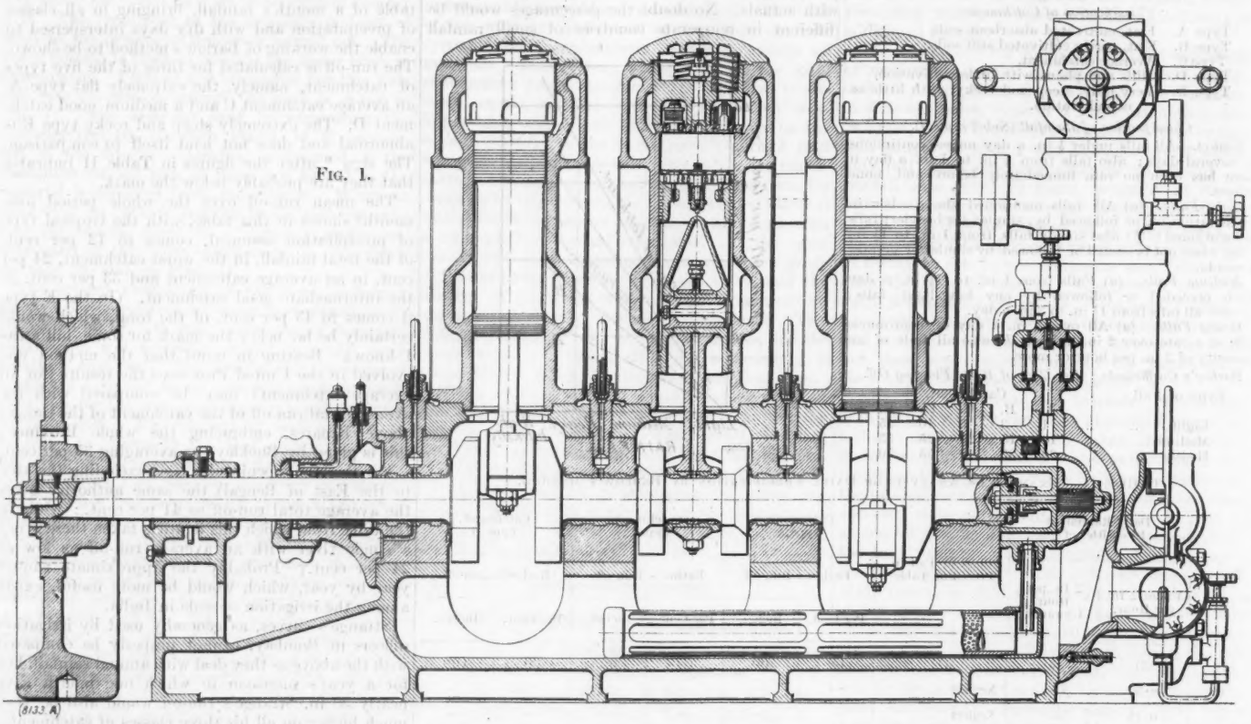
I may add that I am so confident that this method

* *Op. cit.*, page 325.
† *Op. cit.*, page 325.
‡ *Op. cit.*, page 326.

AMMONIA REFRIGERATING PLANT AT BLACKFRIARS COLD STORES.

CONSTRUCTED BY MESSRS. L. STERNE AND CO., LIMITED, ENGINEERS, GLASGOW.

FIG. 1.



is an advance on what has gone before that I used it generally in calculating the "run-off" from "blind" catchment areas dealt with by the hydro-electric survey; but no check on the predictions has become available, since my fractionating rain gauge is only now coming into use.

REFRIGERATING PLANT WITH HIGH-SPEED AMMONIA COMPRESSORS.

THE new refrigerating plant which Messrs. L. Sterne and Co., Limited, of the Crown Iron Works, Glasgow, have recently installed for the Blackfriars Cold Storage Company, Limited, is interesting not only on account of the great compactness of the arrangement, but also in respect of the design of the compressors employed. Both these features are indeed connected, because only the vertical high-speed type of compressor which was used would permit of so intensive a use of the small space in which it was desirable that the plant should be contained. The compressor room before the alteration had three machines, two of the old De Lavergne steam-driven type, each capable of 65 tons of refrigeration per 24 hours, and another 10 in. by 18 in. horizontal motor-driven compressor with a capacity of 30 tons of refrigeration; altogether a refrigerating capacity of 160 tons was therefore housed in the space available, and this has now been replaced by 300-ton machines, or nearly twice the previous capacity, with a gain in accessibility and convenience.

The type of machine which has rendered this increase of capacity possible has been designed by Messrs. L. Sterne and Co., Limited, as the outcome of a very long experience with refrigerating machinery. The constructional details to which we shall refer later will be understood from Figs. 1 to 4, on this and the opposite pages. The new installation is illustrated in Figs. 5 and 6 on the opposite page. It comprises three motor-driven units, two having each a capacity of 75 tons of refrigeration per 24 hours, while the third has a capacity of 150 tons. The plan shows the arrangement adopted, while a general view of the plant in position is given by the photograph reproduced in Fig. 9, on page 50. The decision to use two different sizes of compressor was based on the desire to reduce the running costs of the plant to a minimum. Electric power has to be purchased on the maximum demand system in which a charge is made not only for the total units consumed, but also in respect of the maximum load which may be taken at any time during a certain period. The duty of a refrigerating plant for a cold-store obviously varies with the time of year, and, during the winter months there are long periods when quite a small proportion of the full capacity of the plant is needed. The use of a small machine fully loaded during such times, not only results in a lower current consumption per ton of refrigeration performed, but furthermore reduces the maximum demand for electricity.

All three of the machines in the installation referred to are of the three-cylinder high-speed vertical forced-lubrication type, directly coupled to variable speed direct-current motors, taking their current from the 440-volt mains. The two smaller sets have cylinders 9-in. bore by 9-in. stroke, and run at 300 r.p.m., while the larger one has cylinders 11½-in. bore by 11½-in stroke, the speed in this case being 250 r.p.m. The three electric motors were supplied by Messrs. W. H. Allen, Sons and Co., Limited, of Bedford, and they are controlled from the three enclosed starting panels shown on the plan (Fig. 6). The design of the ammonia compressors is well illustrated by the sectional drawings reproduced in Figs. 1 and 2. The ammonia gas to be compressed is led to a belt round each cylinder, whence it passes into the cylinder proper through ports. These ports communicate with the lower part of the cylinders, which are isolated, both from the working portions and from the crankcase by sets of rings at the top and bottom of the pistons.

The construction of the pistons will be best understood from the drawings. A pair of large ports through the piston walls just above the gudgeon-pin allow the gas to pass inside the piston into a space bounded at the top by the piston head shut off from the gudgeon-pin and crank-case by a pointed shield. In the piston head are a number of light annular steel valves, which rise from their seats on the downward stroke and admit the gas to the working part of the cylinder. Here it is compressed on the upward stroke, passing away through the spring controlled valves in the head. These latter valves are mounted in a plate which is held down to a machined seating by a heavy cap backed with stiff springs. The object of the arrangement is obvious. To get a really high efficiency in a compressor the cylinder clearance has to be reduced to the utmost limits, for any vapour which is not passed through the discharge valves re-expands on the downward stroke and prevents a full charge being taken in. Furthermore the work done in compressing vapour into the clearance volume is only partially recoverable during re-expansion. Hence, it is essential that the piston shall come almost into contact with the cylinder head on its upward stroke, and this can only be safely allowed if some provision is made that actual contact shall not be dangerous.

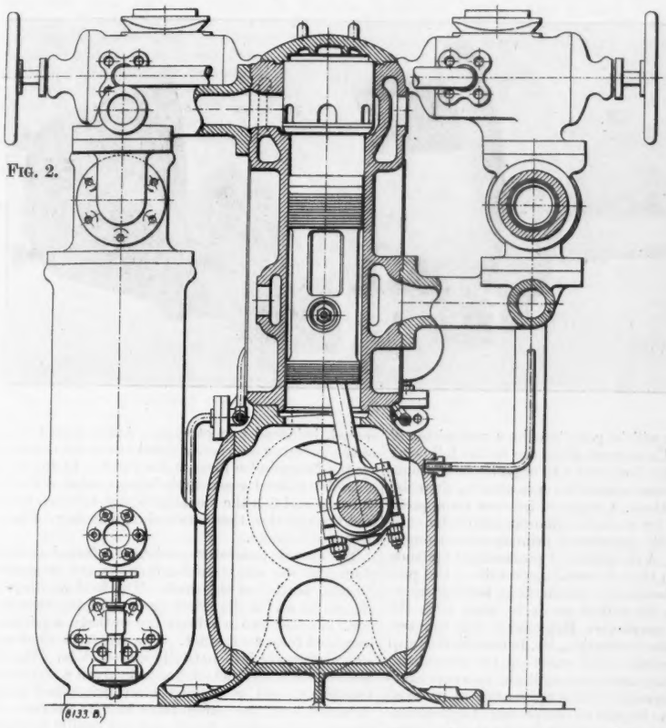
The photographs reproduced in Figs. 3 and 4 show the valves and fittings in the piston and cylinder head. The ease of access to the valves and the facility with which they may be ground in or withdrawn is a noticeable feature of the design. By removing the cylinder cover the cap and the discharge plate with its valves can be at once withdrawn, exposing the inlet valves to view. A wrench terminating in a box-nut can then be screwed on to the projecting stud in the centre of the piston-head. This stud carries a locking plate which prevents the unscrewing of the guards over the valves. By pulling up the wrench the locking plate can be lifted against the action of a spring beneath, and a partial rotation then prevents its return so that the whole of the surrounding valves are simultaneously freed. They can, therefore, be removed and replaced with the greatest ease without the use of a spanner, and, of course, without withdrawing the piston. The valves can be ground to their seats with the piston in position, by means of a special spring collet, which expands under the tension of the grinding handle, and grips the valve firmly by the inner edge of the annulus of metal of which it is composed.

As will be seen from the sectional drawings, forced lubrication is provided for by means of a gear pump driven from an extension of the crankshaft. This pump draws oil from the strainer in the crankcase, and delivers it into a manifold pipe, whence connections are taken to the main bearings. Part of the oil passes through oil holes drilled through the crank

AMMONIA REFRIGERATING PLANT AT BLACKFRIARS COLD STORES.

CONSTRUCTED BY MESSRS. L. STERNE AND CO., LIMITED, ENGINEERS, GLASGOW.

FIG. 2.



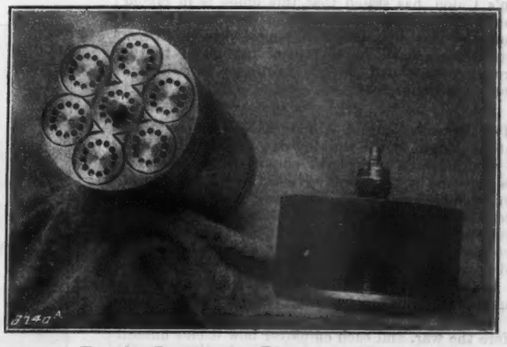


FIG. 3. PISTON AND DISCHARGE VALVES.

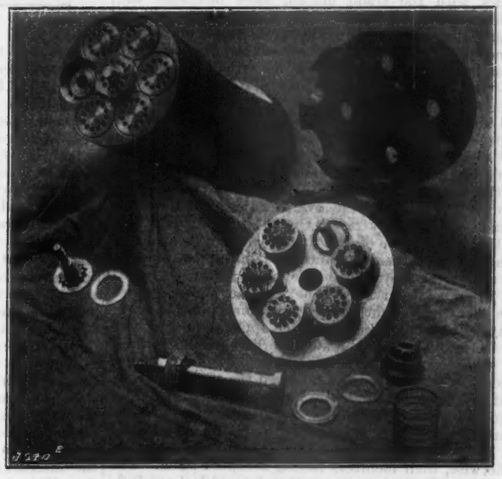


FIG. 4. PISTON AND DISCHARGE VALVES PARTLY DISMANTLED.

Fig. 5.

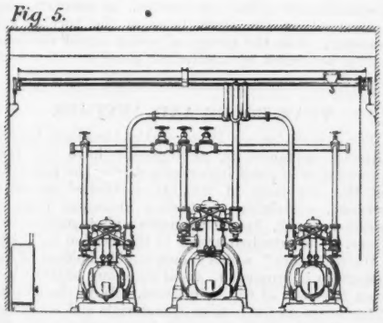
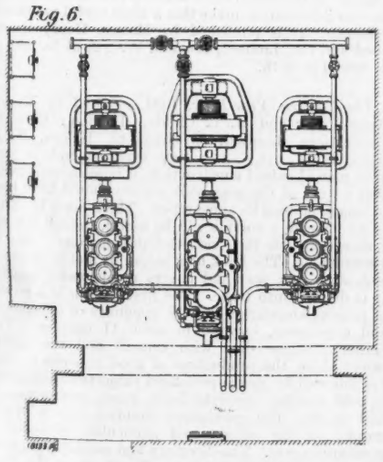


Fig. 6.



webs for the lubrication of the crank pins, and a passage way bored through the centre of the connecting-rods provides for the lubrication of the gudgeon pins. Oil escaping from the main-bearing nearest the flywheel, passes directly to the end of the stuffing-box, where it lubricates the soft packing which surrounds the shaft at this point.

The arrangement of the external piping of the compressors installed for the Blackfriars Cold Storage Company, Limited, will be gathered from Fig. 9, which shows the three machines in position. Being three-cylinder machines, the layout is hardly so symmetrical as it can be made in the case of four-cylinder machines. This will be obvious from Figs. 7 and 8, which illustrate other machines manufactured by Messrs. Sterne for other purposes. The compressor shown in these illustrations has four cylinders, 6-in. diameter by 6-in. stroke, and has a refrigerating capacity of 40 tons per 24 hours when driven at 400 r.p.m.

INDUSTRIAL NOTES.

SPEAKING last week-end at Tamworth, Mr. Frank Hodges, M.P., said that the ballot to be taken on the proposals to terminate or to continue the National Wages Agreement bore no conceivable relationship to the possibility of a Labour Government. He added that the miners would have to establish two vital principles before they could secure even the sympathetic consideration of the Administration—these being that the claim for a living wage had been made out, and that it could be granted without inflicting any injustice upon the rest of the community. In his judgment, "a prolonged stoppage of work in the coal trade this year would destroy all prospects of our economic recovery for another five years," and he did not despair of a peaceful settlement. Competence to arrive at a settlement existed within the industry itself, save for the question of royalties, and there was no need for extra Parliamentary action, provided the desire for peace existed on the owners' side.

Early in the week Mr. J. Bromley, the Secretary of the Associated Society of Locomotive Engineers and Firemen, stated that the ballot of the Society's members on the awards of the National Wages Board for the railways—which are to have effect as from the beginning of the third full pay week this month—showed, so far as it had gone then, an overwhelming majority against acceptance. According to Mr. Bromley, firemen on mileage trains running 135 miles a day stand to lose, under the awards, 9*s.* per week, and on trains running 150 miles a day, 18*s.* per week; drivers on similar mileage trains stand to lose 11*s.* 3*d.* and 22*s.* 6*d.*, respectively, per week. He also disagrees with other awards applicable to his Society. It has since been reported that the actual figures of the ballot are not to be published, a statement being added to the effect that they show a majority of six to one against acceptance. The awards of the Board, of which we gave an abstract in our issue of December 28, were accepted immediately by the companies, although disappointing from their point of view, and by an overwhelming majority by the National Union of Railwaymen; they were accepted later by the Railway Clerk's Association, as stated on page 11 *ante*. The two representatives of the Associated Society of Locomotive Engineers and Firemen present on the Board during its sittings, also signed the report detailing the awards, a fact which, in view of the adverse ballot taken later by the Society's members, complicates the situation between the companies and all three unions—a situation which, it is to be hoped, will be cleared by further negotiations between the companies and the Society now mainly concerned.

The situation in regard to coal tippers and trimmers employed at the docks in South Wales, which seemed to give some promise of improvement, according to the statement we were able to make in our last issue, appears now to have become more acute judging by the following resolution passed at a conference held in Cardiff last Tuesday. The resolution says: "That this conference, having ascertained that the Great Western Railway Company are endeavouring to defeat the decision of the tippers by pressing the temporary tippers to work the third shift, we hereby decide that if that policy is pursued in any of the three ports (Cardiff, Barry and Penarth), we shall immediately recommend the withdrawal of the tippers employed on the other two shifts."

The crews of seven German steamers now lying at

the Hull docks have come out on strike with a view to obtaining the Maritime Board rate of wages. The strike is likely to spread to the crews of other German steamers lying at other British ports. Mr. Havelock Wilson, chairman of the National Seamen's and Firemen's Union, has stated that this union is in favour of supporting the German crews in their endeavour to secure the British standard of wages when in British ports, since a much lower rate of pay given to the German crews tended to react against the British shipowners and their crews.

The Brussels journal *L'Echo de la Bourse* states that the length of the working day in Germany, both for working men and clerks employed in industries, was governed by two bye-laws issued by the demobilisation commissioner. The bye-laws were valid for determined periods, and their validity was extended regularly each time on expiration, except on the last occasion. The bye-law expired last on December 17, and no new ordinance having been issued, there appears to be no official standing-order for governing the length of the working day; the present situation may be said to be comparable to that which obtained before the war, and each employer now deems himself free to act as he thinks reasonable. In the occupied territories, the industrialists, after numerous difficulties with the trade unions, have increased the number of working hours. The mining unions, among others, after considering present conditions, ultimately found that they could not reasonably maintain the seven-hour day, which meant less than six hours' effective work at the coal face. Moreover, the coal-owners had decided eventually to ignore the miners, and had even started engaging men on individual contracts. Miners, at the present time, have a working day of eight hours; they spend, therefore, one hour more in the mine. One hour has also been added to the working day of the surface men. This extra hour is not paid on the overtime basis, but on the normal working day rate. On February 1, delegates of the coalowners, of the unions and of the Labour Ministry, are to meet, and if the coal output has reached pre-war level they will decide upon further steps to be taken as from May 1 next. The above applies specially to the Ruhr district, but mines in other parts of the country are considering the application of similar measures. The iron and steel workers' unions refused to agree to an effective working day of 10 hours, when the works' owners discharged the trade unionists and re-engaged men upon individual contracts, the men being eager to accept the owners' terms as to working hours. A number of trade unions finished by agreeing also to these terms—they could not do otherwise, their members having accepted them. The eight-hour day measure may thus be said to have been abandoned in Germany, and when the Reichstag is less busy on other matters it will no doubt pass the necessary legislation establishing the longer day. Reports have reached us from other quarters to the effect that besides the longer working day which the men have agreed to, they have also accepted a decrease in wages.

According to *The Iron Age*, New York, figures prepared by the National Industrial Conference Board show that the cost of living of the average wage earner was higher in November than at any previous time within the past two years. It is placed at 65·3 per cent. above the 1914 figure, the principal increase during the month being in rent, which now stands 80 per cent. higher than pre-war. Increases occurred also in food and sundries, while decreases were recorded in clothing, fuel and light. Compared with July, 1914, the purchasing value of the dollar is now figured at 60·5 cents.

When the final accounts of 1923 are cast up, says *Iron Trade Review*, Cleveland, Ohio, it will be found that the past 12 months will have registered one of the greatest industrial years in the history of the United States. In some respects the year was without a parallel in the sustained level of plant operations and in the magnitude of general production. Clearly, it was the leading industrial year since the war in point of gross volume. Furthermore, to all appearance, its activity was raised upon a sounder and more stable foundation than its nearest post-war rival, the feverish and abnormal period of 1920. Measuring the flow of all business, railroad traffic in 1923 reached the highest total and the largest monthly average ever known. In all probability, steel production established its largest peace-time tonnage, and was second only to the war year of 1917.

The discussions on apprenticeship at meetings of the Société des Ingénieurs Civils de France, to which we referred in a former issue, have come to a close without any very definite results. Two resolutions were put forward, and they will be gone into by a committee of the Institution. These resolutions are to the following effect:—The Public Authorities to organise in conjunction with the various industrial, agricultural, financial and trades federations, a series of lectures on apprenticeship, followed by visits to different establishments, to both of which the parents of primary school pupils would be invited. A certificate of professional aptitude to be delivered to the successful apprentice; the programmes and subsequent examinations leading up to the certificate to be unified so as to meet with the approval of the employers throughout the country. The president of the Institution, Mr. L. Guillet, summed up the various points which came up for discussion; among these we may mention a uniform apprenticeship indenture, the payment to the apprentice of a fixed wage, a premium to be paid on completion of apprenticeship, collaboration between the State and the employers in regard to apprenticeship, motion study to be considered from the very commencement of apprenticeship, attention having been called to the indifference shown by many employers to the question under review. Information was given during the discussions in regard to the complete apprenticeship systems of the Chantier and Ateliers de St. Nazaire and of Messrs. Bonvillain and Ronceray.

SMALL TURBO-GENERATOR LIGHTING SET FOR OUTDOOR USE.

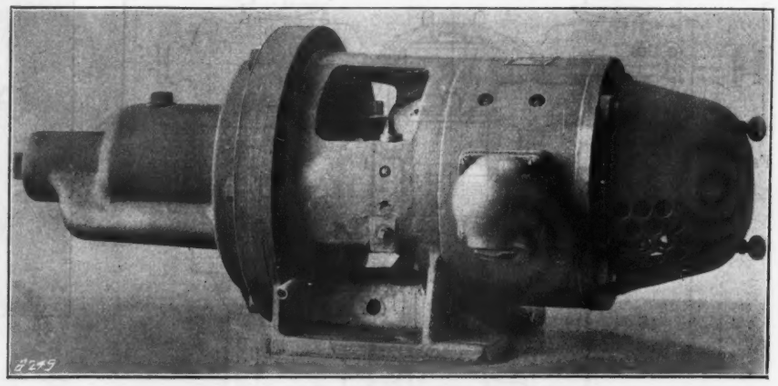
A SMALL non-condensing steam turbo-generator intended for use in connection with such plants as steam shovels and oil-well rigs and for outdoor constructional work generally, is illustrated in the above figure. The machine, which is constructed by the Westinghouse Electric and Manufacturing Company, of East Pittsburg, Pa., U.S.A., is also suitable for service on tug-boats and other small craft, as the generator coils are impregnated to stand a damp atmosphere, and metal parts are sheradised. The set has an output of 1,500 watts at 115 volts direct current and is intended for lighting work. The construction throughout is simple and rugged, and the machine consists only of five moving parts and five castings. The moving parts are the shaft carrying the generator, armature and turbine rotor, two governor weights, the governor spindle, and the valve stem. The set requires no bedplate or foundations, the whole unit being supported by feet on the middle casting, which contains the generator inboard bearing. It may be bolted down to any substantial horizontal support. The complete unit is 32⅝ in. long by 14½ in. wide by 12⅝ in. high, and weighs 250 lb.

The turbine rotor is a solid forging with the buckets milled on the inside periphery of an overhanging flange, which is integral with the disc. The steam nozzle and reversing bucket are die-cast in a single block of bronze alloy, which is bolted to the inside of the turbine cylinder. The steam from the nozzle impinges on the rotor buckets and gives the rotor an impulse in the desired direction. This absorbs part of the velocity of the steam, which then passes to the fixed reversing bucket, where its direction is reversed and it is redirected on the rotor buckets. It then passes to exhaust. The speed of the unit is regulated by a centrifugal shaft-type governor, which is carried in a casing bolted to the rotor disc. The governor acts directly on the valve stem and there are no lever arrangements of any kind. The valve is of the double-seated, balanced poppet type. Apart from the action of the governor, run-away speed of the set is prevented by the flanged-disc form of the rotor. In the event of a predetermined speed limit being exceeded the flange deforms and fills the clearance space between the rotor and the cylinder, thus establishing running contact and acting as a brake.

The electric generator consists of a forged-steel frame ring, and the armature laminations are pressed on a knurled portion of the shaft. The field windings have the shunt and series windings wound together as one coil, but the two windings are entirely separate and insulated from each other. The armature windings are wound directly into partially closed slots. The brush holders are of steel which has been given a rust-resisting treatment, and a pressed steel drip-proof cover is provided over the commutator and its brushes. It is secured by two wing screws and can readily be removed for examination of the commutator. A ventilating fan is mounted on the shaft between the turbine and generator, while the escape of steam round the rotor shaft is prevented by a labyrinth gland.

SMALL TURBINE-DRIVEN LIGHTING SET.

THE WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, EAST PITTSBURG, PA., U.S.A.



YEAR BOOKS AND ANNUALS.

The British Journal Photographic Almanack, 1924.—Although advances in photography have not been numerous or of great importance during the past year, yet the new issue of this old-established annual is welcome, containing as it does numerous pages of varied formulæ, &c., for different photographic processes. The principal article in this edition is "Using a Hand-Camera" which should enable holders of this ubiquitous instrument to avoid the many pitfalls which beset the path of the uninitiated. As in the editions of former years the notices of materials and apparatus, "helps" in the studio and workshop practice, tables and various information make this a most useful volume of reference. It is published by Messrs. Henry Greenwood and Co., Limited, London, W.C. 2, at 2*s.* net, or 3*s.* bound in cloth.

The Concrete Year-Book, 1924.—Edited by Messrs. Oscar Faber and H. L. Childe. London: Concrete Publications, Limited, 35 Great St. Helens, E.C.3. (Price 2*s.* 6*d.* net.)—At a time when concrete is used in so many kinds of construction, it is rather surprising that a work of the year-book variety should have been so long in making its appearance. There must be many to whom such a volume will be useful, though how far it should include the "non-technical manner" may be questionable. The book now before us makes an excellent start this year and covers much useful ground. It is divided into three. The first section is a review of present knowledge and the teachings of experiment and experience, covered in some 11 chapters. The earlier of these deal with cement and the factors essential for the production of good concrete; these are followed by more specialised subjects as concreting in cold weather, concrete floors, roads, reinforcement, and so on. The concluding chapters give a bibliography on the subject and particulars of technical institutions, etc. The directory and catalogue sections which conclude the volume will not prove the least useful parts of the book, as they have been well done. Though inevitable, it is to be regretted that the editors have been compelled to draw so largely on American sources of information regarding qualities. We hope the constant reference to American investigations will

be sufficiently striking to stimulate on this side more research worthy of permanent record.

The Swedish Year Book, 1923.—We have received from the Swedish Consulate-General in London a copy of this year book, which is printed in English, at Stockholm. It contains a large amount of interesting information on the Swedish Constitution, Government, State finances, natural resources, industry and mining, trade, shipping, etc., also short surveys of different phases of Swedish social and economic life, and chapters on the history, art and literature of the country. The book is admirably printed and illustrated, and forms a most handy book of reference on Sweden. The publishers are Messrs. Almqvist & Wiksells Boktryckeri A.B., Stockholm.

Marconi's International Register.—The full title of this book for 1923–1924, is "International Register of Telegraphic and Trade Addresses," with which is incorporated the "Marconi International Directory of Cable Addresses and Code Users of the World." It measures 13 in. by 10 in., and contains about 2,200 pages. The first section is arranged alphabetically as regards names of firms located in every quarter of the globe, and gives opposite each name a five-letter code word, the principal codes used by the firms, with the cable addresses; the second section giving the firm's names and addresses classified under trades; the trade names and professions are translated into Dutch, French, German, Italian, Portuguese and Spanish in a third section, the fourth giving the cable addresses arranged alphabetically and the corresponding code word. The object of the register is to enable importers and exporters to get into rapid business communication with each other, and thereby to develop international trade. The book also forms a most complete directory, and one advantage claimed for the coding system adopted is that the code words it gives can be used in conjunction with most standard codes. Its compilation must have entailed work of a most complicated nature, and its publishers, The Marconi International Code Company, Limited, Marconi House, W.C.2, and Code Users Inc., 111, Leonard-street, New York, U.S.A., are to be congratulated on its successful issue. Congratulations are also due, in our opinion, to the printers, Messrs. Harrison and Sons, Limited, 44–47, St. Martin's Lane, W.C.2. The price of the register is 52*s.* 6*d.* net.

Who's Who, 1924.—The present edition of this well-known biographical dictionary, the seventy-sixth year of issue, has now appeared in its usual form, and contains the biographies—to the extent, it is stated, of over 30,000—of men and women occupying responsible positions both in this country and abroad. The biographies include the titles and distinctions under each name entered, the addresses, services rendered, experience gained and work carried out, the position held, and other information of interest. The book contains 3,110 pages of subject-matter, neatly printed as in former editions and easy of reference. The high standard of the work is maintained, and the present edition, like all former ones, will be greatly appreciated, not only in this country, but in foreign countries also. It is published at the price of 42*s.* net, 43*s.* by post, by Messrs. A. and C. Black, Limited, 4 to 6, Soho-square, W. 1.

The Colliery Manager's Pocket Book, 1924.—This year book deals with matters of interest to all who are concerned, directly or indirectly, with the mining and the utilisation of coal, although, as its title implies, it appeals primarily to colliery managers. Various subjects are entered into in detail, such as the control of atmospheric conditions in deep and hot mines, the coal-dust problem, mining explosives, miners' lamps, the spontaneous combustion of coal, subsidence in mines, the preparation of coal previous to its use, engineering and electricity in mines, &c. Statistics relating to coal are given, also mathematical chapters on mining in all its branches, tables for reference in calculations appertaining to coal mining and the utilisation of coal, information for the guidance of candidates to situations in the mining profession, &c. It further contains an almanack, diary, cash and memoranda pages, and general information. The book is edited by Messrs. J. Vincent Elsden and Hubert Greenwell, and is published at the price of 3*s.* net, by The Colliery Guardian, Ltd., 30 and 31, Furnival-street, Holborn, E.C. 4. The success of the publication is emphasised by the fact that the present is the fifty-fifth annual edition.

Diaries.—We have received from the Staveley Coal and Iron Company, Limited, Staveley Works, near Chesterfield, a handsone pocket case, containing two booklets, one giving particulars of their manufactures and a large number of reference tables of weights and measures, the other being a diary and note-book. A very useful pocket case and diary also reaches us from the Ingersoll-Rand Company, 165, Queen Victoria-street, E.C. 4, containing a diary and note book giving technical data and references for the use of engineers. A neat leather-bound diary comes to hand from the General Electric Company, Limited, Magnet-House, Kingsway, W.C. 2, which gives particulars of their Osram lamps. Also a diary from Messrs. Metchim and Son, 8, Princes-street, S.W. 1, and 32, Clement's-lane, E.C. 4, containing a number of surveyor's tables and other data of use to contractors and builders, carefully indexed. One from the Industrial League and Council contains information concerning it and concerning various unions and public bodies; the head offices of the League and Council are at 82, Victoria-street, S.W. 1.

Almanacks and Calendars.—We have received monthly tear-off calendars from Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, Newcastle-upon-Tyne; Messrs. Crossley Brothers, Limited, makers of oil engines, gas engines and gas plants, Openshaw, Manchester; Messrs. Hollings and Guest, engineers, Thimble Mill-lane, Birmingham; the Gear Grinding Company, Limited, Anne-road, Handsworth, Birmingham; Messrs. Peckett and Sons, Limited, locomotive engine builders, Bristol; Messrs. Aiton and Co., Limited, Derby; Messrs. Hulse and Co., Limited, machine tool makers, Ordsal Works, Manchester; The Brown Hoisting Machinery Company, Cleveland, Ohio; Mr. Joseph Collard, manufacturing stationer and printer, 43, Charing Cross-road, W.C. 2; the Beldam Packing and Rubber Company, Limited, 29, Gracechurch-street, E.C., Brentford, Paris, New York, &c.; Messrs. Geo. Cradock and Co., Limited, Wakefield; Messrs. John I. Thornycroft and Co., Limited, Southampton and Basingstoke; Messrs. Wm. Clowes and Sons, Limited, Duke-street, Stamford-street, S.E. 1; Messrs. Haslam and Stretton (Engineering and Motor Utilities, Limited), Cardiff, Bristol and Swansea; Messrs. H. W. Ward and Co., Limited, machine tool makers, Dale-road, Selly Oak, Birmingham; Messrs. Beecroft and Partners, consulting, foundry and analytical chemists, St. Peter's Close, Sheffield; Messrs. C. A. Parsons and Co., Limited, Heaton Works, Newcastle-on-Tyne; Messrs. Urquhart Lindsay and Robertson Orchar, Limited, associated with Fairbairn Lawson Combe Barbour, Limited, Leeds, Belfast, Dundee; Messrs. John Holroyd and Co., Limited, machine tool makers, Milnrow, Lancs. The Westinghouse Brake and Saxby Signal Co., Limited, 82, York-road, King's Cross, N. 1; Messrs. Adam & Co., builders and electrical engineers, 225, Blackfriars-road, S.E. 1; the Ironite Co., Ltd., 11, Old Queen-street, S.W.1, and Trafford Park, Manchester; the D.P. Battery Co., Limited, Bakewell, Derbyshire; the Westinghouse Electric International Company, 2, Norfolk-street, Strand, W.C.2; Messrs. Marshall, Sons and Co., Limited, Engineers, Gainsborough; Messrs. R. Y. Pickering and Co., Limited, engineers, Wishaw, Beighton, Rawyard, Thornton Junction; and from Messrs. W. H. Willcox and Co., Limited, 58, Southwark-street, S.E. 1.

A series of weekly refils has come to hand from the Welin Davit and Engineering Company, Limited, Liverpool, Southampton, London and Paris, which, on the stand specially made for it, forms an admirable desk calendar. Also a yearly calendar for 1924 and 1925, with monthly ones for January, February and March, 1924, from the Brookhirst Switchgear, Limited Northgate Works, Chester.

Daily tear-off calendars have reached us from Messrs. Henry Simon, Limited, 20, Mount-street, Manchester; Messrs. Vernon Proctor and Co., iron and steel merchants, Foster's Buildings, 22, High-street, Sheffield; Messrs. Newton, Chambers and Co., Limited, Thorncliffe Iron Works, near Sheffield; Messrs. Harrison and Sons, Limited, 44-47, St. Martin's-lane, W.C. 2, and Hayes, Middlesex, combined with monthly sheets; the English Electric Company, Limited, Preston, Coventry, Bradford, Stafford and Rugby; Messrs. Ashwell and Nesbit, Limited, engineers and iron-founders, Leicester, London, Liverpool, Glasgow, &c.; Messrs. John Tullis and Son, Limited, St. Ann's Works, Glasgow; Messrs. Thomas Robinson & Son, Limited, Rochdale, London, and Sydney; and from The Davenport Engineering Co., Limited, Bradford and Hull.

A useful weekly almanack with space for daily notes has reached us from Messrs. John Fowler and Co. (Leeds), Limited, Steam Plough Works, Leeds, and 113, Cannon-street, E.C. 4. Also a calendar in a well-got-up metallic case from the Reason Manufacturing Company, Limited, makers of electrical indicators, meters, time switches, &c., Brighton, with device for blocking out past dates; and a weekly tear-off calendar from The British Chemical Plant Manufacturers' Association, 166, Piccadilly, W.

PERSONAL.—Messrs. W. H. Willcox and Co., Limited, 38, Southwark-street, S.E. 1, state that their telegraphic and cable addresses are:—Telegrams: "Enginsplys, Boroh, London." Cables: "Enginsplys, London."

NOTES ON NEW BOOKS.

Books written or compiled on lines dictated by a prepared syllabus and intended to assist candidates to satisfy examiners in selected subjects are rarely satisfactory, and we cannot say that the work on "*Hydraulics*," by Mr. E. H. Lewitt, B.Sc. (Pitman and Co., London; price 8*s.* 6*d.* net) is any exception to the class. The closer a writer keeps to a predetermined path, the more he is willing to suppress himself and follow in the steps indicated, the less originality can he show and the fewer opportunities he has for bringing his own experience as a teacher to bear upon the subject. Examinations, affording an easy method of selection, and on that account beloved by the official mind, too often exercise a controlling force over education, and delay the development they are intended to test and encourage. There are those apparently who think that the object of education in this country has, or can have, no higher aim than to enable a candidate to pass an examination at a specified age. Mr. Lewitt no doubt hopes that his treatment of the elementary principles of hydraulics will be of assistance to those who are working for an engineering degree. Such hopes are warranted, for he has studied the grooves in which the examiner's mind works, knows precisely the limitations imposed by the syllabus, and adapts himself to meet its requirements. But we believe Mr. Lewitt would have written a better book if he had followed his own intuitions. It would have been more original in construction, more consecutive in design, with greater freedom in illustration and more stimulating in its effect. Under the circumstances the scope is so narrowed that little need be said of the contents, which follow the usual lines of such elementary works. We have two chapters on the static pressure and buoyancy of fluids, illustrated by reference to metacentric height, and we wonder how many will grasp the fact that water does not behave as an ideal fluid, and that in practice pure theoretical hydraulic investigations have to yield to empirical rules. Other chapters deal with water in motion as seen in the flow through orifices and over notches and weirs. Francis and Bazin's formulæ for rectangular weirs are deduced, and we are grateful to the author for not discussing more of the wearisome formulæ that Chezy and others have devised, since these are of little use while the constants or factors, are so uncertain. The measurement of water in channels and the use of the current meter are admirably treated from an elementary point of view, but we think the author has travelled away from the record or is getting away from his brief, when he describes the rain gauge and discusses the quantity of water supplied per head to the population of large towns. The principles of hydraulics are applied to the mechanism of reciprocating pumps and of turbines and centrifugal pumps, the concluding chapter being devoted to water meters and some other appliances, but naturally a full treatment of such varied applications is impossible. Examples involving numerical calculation are plentifully scattered throughout the several chapters, and as the greater number of these are taken from examination papers, they show both that the information supplied in the text is sufficient to meet the demands of the examiner and test the capacity of the pupil to turn the information to account. The printer who has substituted cosecs for cuscs has unwittingly given a very quaint form to one of these examples.

A book for German electricians who wish to complete their knowledge of the English language and of English technical terms in the realm of electricity is entitled "*Englisch für Techniker; Elektrotechnik*," by Dipl. Ing. Carl Volk. It is made up of abstracts from a number of British and American books and journals on electricity. The subject-matter is throughout in English, the principal technical terms being translated into German for the guidance of the readers. The book measures 6 in. by 4 in., and contains 115 pages with a few illustrations. It is quoted 1*s.* and forms part of the Göschen series, issued by Messrs. Walter de Gruyter and Co., Berlin and Leipzig. Its object is also to serve as a reader and exercise book for students in German technical schools.

Often the biographer or historian departs from the narrow path of impartiality when the opportunity arises for him to bring forward some particular view of a subject. True perspective is difficult to maintain, and would often result in colourless records, so that the biographer at least is forgiven some slight distortion. An official historian, however, must get as near as possible to cold facts and leave them at that. The historical notes embodied in the catalogue of the collections of the Science Museum, South Kensington, are for this reason not calculated to sweep us off our feet in enthusiasm for one inventor or another, but so far as history is known the facts are all recorded

in their correct relation and form a valuable guide to developments in various directions. The section for "*Land Transport, III, Railway Locomotives and Rolling Stock*" (published by H.M. Stationery Office, Kingsway, W.C., 1s. net) has been compiled by Mr. E. A. Forward, who gives in an introduction an excellent condensed review of the development of the locomotive, while notes are supplied on all the exhibits from which their historical value may be appraised. These often touch upon cognate matters such as developments to which the actual model under notice, led, so that the material is not so dry and devoid of life as a catalogue often proves to be. The notes are well compiled and will doubtless come to be quoted as authoritative on particular points, as they should, of course, be under the circumstances. The catalogue has its value enhanced by many excellent illustrations.

THE MÜLLER X-RAY SPECTROGRAPH.

THE simple X-ray spectrograph which we illustrate in Figs. 1 to 9 on the present and opposite pages, was constructed by Messrs. Adam Hilger, Limited, to the design of Dr. A. Müller, who has for some time been working in London. The instrument meets the demand for a spectrograph which can be utilised for work by several of the chief photographic methods now in use, and it differs from other spectrographs by this wide range of applicability and by its extreme compactness. Each of the methods of working above referred to has its advantages for special purposes, as well as its difficulties of interpretation.

In the original Laue method by which J. Czochralski obtained the remarkable photographs for his investigation of stress-strain phenomena, which we illustrated on pages 750 and 762 of our issues of December 14 and 21 last, the pencil of X-rays traverses the specimen, a crystal or foil, and produces on the photographic plate behind it a pattern of many spots due to the scattering and diffraction of the rays by the atoms which the rays encounter. The Müller spectrograph is not intended for this mode of working. It is designed for the use of methods known as reflection methods, though the phenomena actually observed are different from ordinary surface reflection and are also diffraction effects. The X-rays do not, or need not, traverse the specimen, but they penetrate into it to a certain depth, and are more and more absorbed as they pass through the successive parallel layers or planes in which we imagine the atoms to be grouped. The pencil of rays, which should be all of the same wave-length, falling upon a crystal face at a certain angle θ, will be reflected at the same angle. The absorption and reflection at each single plane are far too faint to be perceptible, however, and it is only when the vibrations in the reflected beams from a very large number of successive planes reinforce one another that we obtain measureable effects. That will happen whenever $n\lambda = 2d\sin$, where n is the number of planes, d their distance apart, λ the wave-length of the rays used, and θ the "glancing" angle which they form with the plane on which they impinge. When there is pronounced reflection in the direction θ, a spectrum line appears on the photographic plate; if we turn the crystal so that θ changes, the direction of the reflected beam will not shift, as it would with a mirror and visible light, but there will be no reflection at all (or merely some diffused reflection) until the relation $n\lambda = 2d \sin \theta$ is again satisfied for new values of n, d, θ.

From the formula $n\lambda = 2d \sin \theta$, which we owe to Sir W. H. Bragg and his son, Professor W. L. Bragg, we can calculate the d, the spacing of the atomic planes, if the λ be known, and the λ if the d be known, in simpler ways than is possible with the Laue method; in any case some knowledge of the crystal system is a valuable and sometimes, indeed, indispensable help. Since we may imagine many series of planes passed through the atoms of a crystal, we shall obtain different spectrum lines—differing both in position and in intensity—corresponding to the several crystal faces and planes, as we present the crystal in different orientations. To do this, the crystal is, in the Müller instrument, oscillated to and fro' by means of a slowly-moving spring motor.

For working by the Bragg method, a well-developed crystal face, at least 1 mm. square, should be available; such faces are not always obtainable, and working with very small crystals is very difficult. But following up an observation of Laue and his collaborators, P. Debye and Scherrer, in 1916, and A. W. Hull, in 1917, described modifications of the reflection method applicable to crystalline powders and to rods and wires. The material is broken up into minute crystalline particles (possibly microscopic), which are then lightly compressed, with the aid of some binding agent like collodion, into thin rods, about 1 mm. in diameter, or filled into fine tubes of glass, paper, or celluloid. When a pencil of monochromatic X-rays strikes this rod or tube normally, there will, among the many minute crystals lying in all directions, be one or a few at suitable incidence θ_1 to give the line corresponding to that angle and plane, others at angle θ_2 to give another line, &c., whilst there will also be a general diffused "white" reflection too faint to produce any definite line. Instead of a rod of powdered particles we can also use a thin wire. Further, we can glue the powder to a piece of paper or mica through which the rays are passed, and a mere streak of the material will be sufficient for this examination.

The Müller spectrograph is now so built up of interchangeable parts that the one or other of the methods indicated, of Bragg, Debye or Hull, may readily be used. The photographs, Figs. 1 and 2, show the general arrangement of the instrument, the drawings, Figs. 3 to 5, explain detail, and the photographs, Figs 6 to 9, exemplify results obtained. The top of the box on which the support for the rotating table and other parts are mounted is better seen in Fig. 2 than in Fig. 1; the latter explains the Bragg arrangement, which we will first describe. The box, 7½ in. long by 4½ in. wide, contains the spring motor mentioned; the motor runs for nearly 8 hours without rewinding and gives 40 oscillations per hour to the shaft which projects from the top of the box. A cam disc is fixed on the shaft; different cam discs, of different arcs, are supplied for obtaining oscillations through different angles; the usual oscillation arc is 12 deg. A lever which can be clamped at any orientation to the axis of the crystal table is kept in contact with the cam, by a spiral spring shown in Fig. 2. The support carrying a rotating table for the crystal mount is seen on the right-hand side of Fig. 1; the X-ray bulb would be further out. Through the crystal mount passes a steel bar, triangular in section, upon which slide the carriers for the slit and the plate holders. The crystal mount consists of a vertical plate fitted with a lead screen to which the crystal can be attached; the mount can be traversed in a slide across the rotating table so as to bring the face of the crystal up to the axis of rotation; the circular edge of the table is divided in degrees to facilitate the setting of the table relative to the lever in order to register lines upon each side of the normal to the photographic plate.

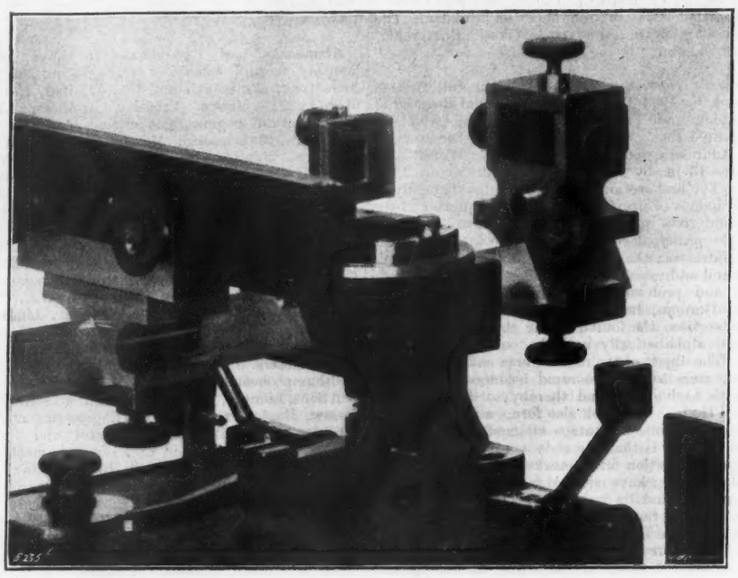


FIG. 1.

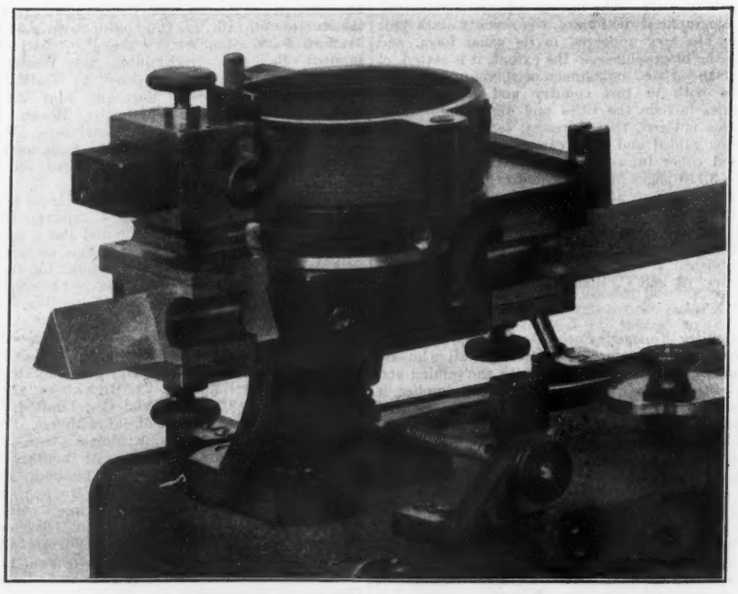


FIG. 2.

Particulars of these parts and of the holders for the crystal and slit, with their carriers, are given in the drawings, Figs. 3, 4, and 5. In these views A is the divided circle. By means of the screws S_1 and S_2 and a spiral spring, the plate holder can be shifted laterally on the table; by means of the screw S_3 and a small spiral spring at the top of the holder, the frame

can further be tilted about the pivot P. In Fig. 4 we see the parts in plan. The crystal C is fixed, by means of a lump of wax W, to the lead screen L which is flanged at the sides and backed by a brass plate. The parts C and W appear rather thick in the diagram. The front of the crystal C should just be grazed by the rays issuing from the slit S (Fig. 4), when the circle A

Fig. 3.

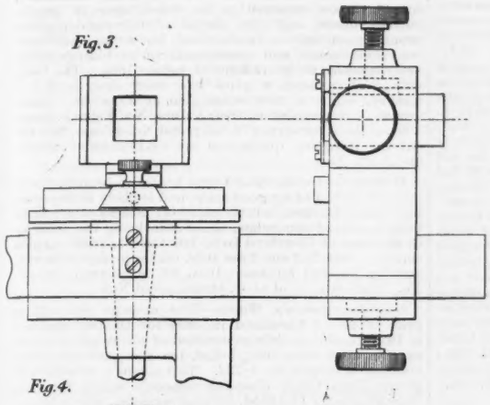


Fig. 4.

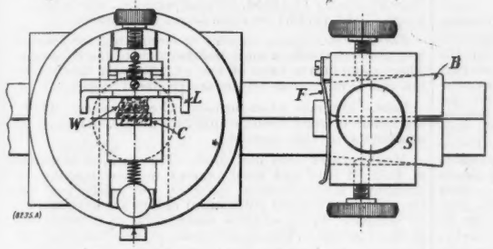
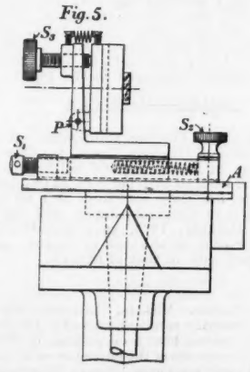


Fig. 5.



is in zero position; the crystal is not really used in this position, but will always be turned more or less, so that the rays strike the crystal face at grazing incidence or various angles. The vertical slit consists of two brass blocks B, each 26 mm. (1 in.) in length, which are fixed at the desired slit-width with the aid of the screws shown and "feeler" gauges (thin blades of steel) which are supplied with the instrument and inserted between the jaws before clamping. The slit width may range from 0·02 mm. up to 1 mm. or more; the height of the slit is 1 cm. The flat spring F (Fig. 4) is only wanted when working by the Hull method; in that case a streak of the material is produced on a foil of mica or paper which is inserted between the face of the slit and the spring F; the crystal holder is removed.

The black box which in Fig. 1 is seen to the left of the crystal holder, is the plate holder; it is attached to the carrier sliding on the prismatic bar by two screws with milled heads. The plate holder is a long box, standing on its narrow side, open in front (not visible in Fig. 1) to receive the photographic film of 4¼ in. by ¾ in. (12 cm. by 1·9 cm.), which can be cut from standard photographic sizes. In its holder the film is covered by a screen of black paper, which does not interfere with X-rays, but keeps ordinary light out so that the apparatus may be worked in daylight without any special plate sheath and without risk of fogging the plate. Fogging of the plate by any stray X radiation is prevented by means of a lead screen mounted on the box. We should mention that the instrument is designed for work with soft rays, ranging from about 2·5 A.U. down to 0·2 A.U. in wave-length; these rays would be much too soft for ordinary therapy, and it is on that account that brass can largely be substituted for lead in the construction of the instrument, and that special protection of the workers is hardly required. There is, however, some risk of static charges by induction from the X-ray bulb and the transformer or machine exciting the bulb; to minimise that risk the milled heads of the screws of the instrument and also of the three levelling screws on which the box rests are made of vulcanite.

So far we have particularly referred to the arrangements required for experimenting by the Bragg method. When the Debye method is to be applied the crystal mount, plate holders and slit jaw are removed, and the carriers are moved up to support a circular camera, 6 cm. in diameter (Fig. 2). The interchange will hardly take more than a minute. The cylindrical shell of the box is hinged to open out and is held closed by an elastic belt encircling the outside; the photographic film is placed inside, the film front being again covered by black paper. The slit previously mentioned is replaced by a block of brass pierced with a central hole, about 1 mm. in diameter; the end of this block fits into an aperture of the camera and points directly to the tubular powder holder or wire inserted into a hole in the centre of the rotating table. Very exact centreing of the material is not required as long as the diametrical beam of rays finds material in its path. The film is also pierced at the entrance of the rays, and there is a small hole in the camera on the opposite side for the rays to leave. The container tubes may be made by greasing a wire, dipping it into a celluloid solution and slipping the dried sleeve off the wire.

Though the instrument is not designed to serve as an exact spectrometer, the photographs, Figs. 6 to 9, will demonstrate that good spectra are obtained. The photographs, Figs. 6 to 8, were produced by the Bragg method. A Shearer X-ray tube was used, with a slit width of 0·02 mm., the plate being about 6 cm. from the rock salt crystal. In Fig. 6 the anticathode was of copper, and the Kα and Kβ lines of copper are shown with a 15-minutes' exposure; the central white line is in all the three cases the direct image of the slit. Fig. 7 was obtained with an amalgamated anticathode of copper, cooled by water circulation; the lines shown with an exposure of 30 minutes, are again the Kα and Kβ lines of copper and further the Lα and Lβ lines of mercury. For the experiments of Fig. 8 an anticathode of platinum was used; the L lines of which are shown; in addition a "white" diffused radiation is visible in the middle portions of the spectrum, which also appears strongly in Fig. 9. In these cases the film was lying straight in the plate holder during the exposure.

When, with the Debye and also the Hull methods, the ring camera is used, the film is curved to a cylinder during the exposure so as to receive the diffraction beams which radiate from the material in the centre of the camera as a series of conical surfaces of common apex, but different apex angles. The photograph, Fig. 9, shows the film as it appears flattened out. The dark round spot seen in the centre (the ray slit is cylindrical) marks the hole pierced through the film to admit the rays. Near this spot the lines (which correspond to the straight lines of the previous figures) appear curved; further away the curvature is less marked, because the lines belong to cones of large angles; the extreme lines are curved the other way, because they are due to the rays scattered backward.

FIG. 6.

FIG. 7.

FIG. 8.

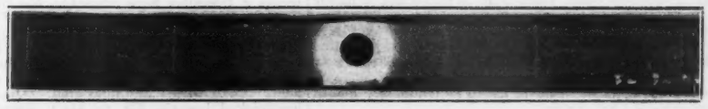


FIG. 9.

An iron anticathode was used; the material examined was a wire of iron: the crystal planes marked by the lines are [220], [211], [200] and [110]. When holder-tubes are used, the spectra may become complicated and be less distinct because the material of the tube itself gives a spectrum. Dr. Müller, last summer, presented a paper to our Chemical Society, in which he showed that the spacings of the carbon atoms in the solid fatty acids can be determined by means of his spectrographs. These paraffin waxes, palmitic and stearic acids and their homologues, consist each of one CH_3 group, one CO OH group and a varying number of CH_2 groups. For his examination he fused a little of the respective fatty acid on a glass plate to which flat, flaky crystals afterwards adhered, parallel with the glass; the plate was then substituted for the rock salt crystal.

BINARY FLUID TURBINES.

TO THE EDITOR OF ENGINEERING.

SIR,—I was brought up in the school of the late Professor Perry, who hammered into us the principles of "truth in numerical work" and the "throwing-away of the superfluous ciphers which arise in the numerical work in physical and engineering problems." Those principles I believe in strongly, and I teach them.

I would like to discuss the following equations from Mr. Kearton's paper, published in your issue of November 23 and 30. If I am wrong I should like to be corrected.

Page 663 (38·2 × 0·8 × 95 × 0·8 = 23·2 per cent.).—If the turbine, generator and boiler efficiencies are not known to accuracies better than represented by the last three factors, why work out the quotient to 0·2 per cent. The same remark applies many times and with other speakers than Mr. Kearton (*see* page 643).

Table I, page 663.—To me it seems absurd to express the vapour pressure of mercury at 32 deg. F. as 0·0000031219 lb. per sq. in. I imagine the original datum is given in millimetres of mercury, to an accuracy of perhaps less than 1 per cent., and that the five figures given in the table are simply due to multiplication by conversion units. The same remark applies to the other tabulated values.

Table II, page 664.—As all the latent heats of vapourisation of mercury are calculated from Clapeyron's formula, plus the value of $\frac{dp}{dt}$ got from the vapour pressure curves, together with the omission of the "liquid volumes" and an approximation to the value of $\frac{dp}{dt}$ what attention should be given to the last two figures in a value 132·97 given for the latent heat of vapourisa-

tion of mercury at 32 deg. F. I should say "None whatever."

Table III, page 664.—Heat quantities given to the thousandth of a B.Th.U., *e.g.*, Net heat supplied = 139·258 B.Th.U. I should say that the data would give, perhaps, anything between 139 and 140. The author might have neglected all the decimals, and his figures would have gained more respect. He could still have got thermal efficiencies to the nearest unit per cent., and these would have answered his purpose.

Section 5. Vapour Pressure Determinations.—1616 deg. F. is evidently a conversion from a quoted temperature of 880 deg. C. This might have been 10 deg. C. out in the original temperature, and the conversion to 1,616 deg. F. gives it quite a spurious accuracy.

The long complicated formulæ giving vapour pressure in terms of temperature are largely empirical and only slightly accurate, as anyone can find out by substituting for temperature and deducing the pressure. This, as Ayrton and Perry have pointed out, is a better test of the formulæ than substituting for pressure and calculating the temperature.

Section 6. Specific Heat of the Liquid.—After studying the vagaries shown in Fig. 6, where Barnes gets results at 400 degrees more than 1 per cent. higher than the other workers, one wonders why Mr. Kearton takes a formula of the type

$$C = a + b\,t + ct^2 + d\,t^5 +$$

and works out a value of a as 0·03369359, and even then uses the formula at temperatures some hundreds of degrees above the limit of the experimental data.

I should be inclined to place an accuracy of less than 1 per cent. on the sensible heats calculated in the table in the middle of page 665; in fact, the three calculated values at a given temperatures differ in some cases by this amount, yet they are worked out to an accuracy of one in two millions.

8. The Latent Heat of Vapourisation.—The calculations involve a knowledge of the critical pressure, as well as many assumptions. The author gives a variety of calculated values varying from 180 to 204 atmospheres, then decides to omit, because it is uncertain, a factor $\left(1 - \frac{p}{pc}\right)$ which might have a value, for $p = 6$ atmospheres of about $\frac{29}{30}$, and deduces $L = 133·2771 - 0·00967505\,t$. This seems to me to be madness. Please correct me if I am wrong.

9. The Specific Heat of Mercury Vapour.—Mr. Kearton assumes a four-figure accuracy for the gas constant and then deduces a specific heat of supposedly five-figure accuracy. But why proceed further? I do not impugn the author's general treatment. I leave that to more competent heads, but I do say that he has wasted much time in his calculations in carrying on his numerical manipulations beyond the reach of reasonable accuracy. This has the effect of exciting incredulity on the part of his readers, and thus his extra work reacts doubly against him.

The general tenor of the remarks I make above apply in many cases in which authors let their arithmetic go "amok." I should like to see someone in authority pull them up. One may smile when similar calculations appear in the public press, but it is high time to stop them when they are expected to be published in reputable journals.

I am, yours very truly,

JOHN SATTERLY.

University of Toronto, Toronto, Canada,
December 25, 1923.

[There is one difficulty attending Professor Perry's oft repeated suggestion of scrapping superfluous decimals. This is a perfectly proper procedure in practical work, where in general no attempt is made to exceed slide rule accuracy as embodied in the common 10-in. rule. It is, however, quite another matter when tables are to be compiled. Very frequently the quantity required is the difference between two tabular values, and if these are calculated to three figures only, the table becomes useless for many purposes. Hence it is often quite proper and legitimate to calculate five-figure tables even if the original data are uncertain by 1 per cent.—ED. E.]

FUEL OIL FOR LOCOMOTIVE FIRING.—In a paper by Mr. J. M. Johnson, of the Missouri-Kansas-Texas Railway, referred to by *The Iron Age*, recently read before the American Petroleum Institute, it is stated that 3½ barrels of oil, or 1,088 lb., are found equivalent to 2,000 lb. of coal. Although the cost of coal at the mine is less than that of its equivalent of oil at the refinery, yet in the final analysis, the adoption of oil has led to a saving on account of other economies.

THE LATE MR. A. W. MACAULAY.—The very sudden death of Mr. Alfred William Macaulay, the technical manager of the Skefko Ball Bearing Company, Limited, of Luton, which occurred on Monday, December 31, has removed, at the early age of 35 years, one of the most enthusiastic exponents of the reduction of the waste caused by friction in machinery. His service with the company started in 1916, and after five years as chief draughtsman, he became technical manager. In the application of ball and roller bearings to heavy duties, such as those found in rolling mills and in electric traction equipment, he did much pioneer work. He was the author of numerous articles and papers on the subject, which appeared in the technical journals and the transactions of the Institutions of Automobile Engineers, Engineers and Shipbuilders in Scotland, Marine Engineers and the Iron and Steel Institute, and a work which he had just completed, entitled "The Ball and Roller Bearing Handbooks," will be published shortly.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—While a more optimistic tone is evident in virtually every branch of the steel and engineering trades, it is easily possible to over-estimate the current measure of revival. The receipt of substantial orders in connection with British railway renewals and constructional schemes has done something to improve the position, particularly at wagon building and locomotive works and at the bar iron mills, but very little benefit has accrued to the special steel branches on which the industries of this district are largely dependent. Overseas buying, while on the upgrade, is a mere bagatelle compared with pre-war requirements. Orders in execution or on makers' books are insufficient to employ anything like the whole of the plant laid down, particularly in view of the large extensions made to productive facilities during the war. Toolmakers, also, who are materially reliant on export business, are by no means at the end of their difficulties, though here again the outlook has slightly improved. The fact that unemployment locally, after a steady contraction, shows an increase as compared with the pre-holiday period, is attributed purely to seasonal influences. The market for raw and semi-finished materials reflects very little change. Steelmakers continue to take a slightly increased tonnage of pig-iron and hematites, though the buying movement has not been sufficient to support any further substantial advance in official quotations. These, as last revised, stand as follow:—Hard basic steel billets, 10*l.* per ton; soft basic steel billets, 9*l.*; West Coast hematites, 6*l.*; East Coast hematites, 5*l.* 5*s.*; Lincolnshire No. 3 foundry, 4*l.* 16*s.*; Lincolnshire forge, 4*l.* 14*s.*; Derbyshire No. 3 foundry, 4*l.* 15*s.*; Derbyshire forge, 4*l.* 12*s.* 6*d.*; bar, 12*l.* 10*s.*; sheets, 15*l.*

South Yorkshire Coal Trade.—The general delay shown by householders, both in London and the country districts in placing their usual stocking orders earlier in the winter, is having an inevitable effect on current market conditions. Supplies would be adequate for all requirements if transport were available, but business has got into arrears, and, under the influence of this, advances ranging from 6*d.* to 1*s.* per ton are notified in best qualities. Industrial fuel values also show a firmer tendency, though so far without any further quotable change. Best steams and washed slacks are very firmly held. Coke prices are unaltered. Quotations:—Best handpicked branch, 33*s.* to 34*s.*; Barnsley best Silkstone, 28*s.* to 29*s.* 6*d.*; Derbyshire best brights, 28*s.* to 30*s.*; Derbyshire best house coal, 23*s.* to 24*s.*; Derbyshire best large nuts, 22*s.* to 23*s.* 6*d.*; Derbyshire best small nuts, 17*s.* 6*d.* to 19*s.* 6*d.*; Yorkshire hards, 22*s.* to 23*s.* 6*d.*; Derbyshire hards, 21*s.* to 22*s.* 6*d.*; rough slacks, 12*s.* 6*d.* to 13*s.* 6*d.*; nutty slacks, 10*s.* to 12*s.*; smalls, 5*s.* to 8*s.*

THE BIRMINGHAM METALLURGICAL SOCIETY.—The No. 8 of vol. VIII. of the Journal of this Society now issued contains three interesting papers, with the discussion thereon, the papers being "Metallurgy and Probability," by Mr. A. Jude; "Some Modern Uses of Zinc," by Mr. Ernest A. Smith; "Optical and Radiation Pyrometry," by Mr. R. S. Whipple.

THE ISHERWOOD SYSTEM OF SHIP CONSTRUCTION.—Shipbuilding returns show that since 1907, when ship construction on the Isherwood system was first started, down to the close of 1923, as many as 1,443 vessels, for a total deadweight carrying capacity of 12,174,490 tons, had been built or were under construction on that system. The ships include 647 general cargo vessels, colliers, ore steamers, passenger vessels, Great Lake freighters, passenger and freight ferry vessels, aggregating 5,794,430 tons deadweight carrying capacity; 664 oil tankers, aggregating 6,306,690 tons; and 132 barges, dredgers and trawlers, aggregating 73,370 tons deadweight carrying capacity. This analysis shows the adaptability of the system.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—In connection with the establishment at University College, London, of the Ramsay Memorial Laboratory of Chemical Engineering, the newly appointed Professor, E. C. Williams, will deliver a public inaugural lecture at University College, on "The Aims and Future Work of the Ramsay Laboratory of Chemical Engineering," on Thursday, the 17th inst., at 5.30 p.m. The chair will be taken by Sir Robert Robertson, F.R.S., who has been closely associated with the establishment of the laboratory, and who is chairman of the Chemical Engineering Sub-Committee. The lecture will be open to the public, and application for tickets should be addressed to the secretary of the College, Gower-street, W.C.1.

CABLEWAY FOR MURRAY RIVER LOCK, WENTWORTH, NEW SOUTH WALES.—A communication has been received from the officer-in-charge of H.M. Trade Commissioner's Office at Sydney to the effect that tenders are invited by the Department of Public Works, New South Wales (Water Supply and Sewage Branch) for the supply and delivery of a cableway, the span of which is to be 870 ft. centre to centre of tower, the head and tail towers to be each 74 ft. in height. The tail tower will be fixed in position and the head tower is to travel on an arc of circle approximately 500 ft. in length. Tenders addressed to the President of the Tender Board of the Public Works Department will be received not later than 2 p.m. on February 25. Further particulars may be obtained by United Kingdom firms on application to the Department of Overseas Trade, 35, Old Queen-street, London, S.W. 1, quoting reference 12946/E.D./E.C./(2).

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—As was anticipated, the holidays have been followed by a steady expansion of business, stocks at makers' yards had accumulated to some extent during the customary suspension of operations at Christmas and New Year by home consumers, but these are expected to be drawn upon to supply current needs, and the output of Cleveland pig-iron promises not only to be absorbed, but to be insufficient for requirements, and consequently more blast-furnaces are expected to be re-kindled before long. The only change of moment in price is a sharp drop in No. 1 quality, which is now obtainable at 102*s.* 6*d.* Other grades of iron maintain their values, No. 3 g.m.b. being 100*s.*; No. 4 foundry, 97*s.* 6*d.*; and No. 4 forge, 96*s.* 6*d.* All the foregoing quotations are f.o.t. makers' works, and f.o.b. Tees.

Hematite.—In the East Coast hematite branch, home demand is on a fairly good scale, and is likely to improve, but export business is little heard of. Stocks of hematite have increased somewhat, the reason being the same as in the case of Cleveland iron, but there is little surplus supply. Nos. 1, 2 and 3 are 102*s.* 6*d.* for prompt delivery, and for forward business, 103*s.* 6*d.* is generally asked. No. 1 hematite is put at 1*s.* above mixed Nos.

Blast-furnacemen's Wages.—The average net selling price of No. 3 Cleveland pig-iron for the last quarter of 1923 has this week been certified at 95*s.* 0·99*d.* per ton, as compared with 99*s.* 7·72*d.* for the previous three months—a drop of 4*s.* 6·73*d.* This means a reduction in North East Coast blast-furnacemen's wages for the current quarter of 10·5*d.* (10½d.) per cent., which leaves wages 27·5*d.* (27½d.) per cent. above the standard.

Foreign Ore.—Some inquiry is circulating for foreign ore, and sellers take a more hopeful view of the situation. They quote on the basis of 25*s.* c.i.f. Tees for best rubio, but this is more than buyers are prepared to pay.

Coke.—Durham blast-furnace coke is easier. There are sellers of good medium qualities at 37*s.* delivered to consumers in this district.

Manufactured Iron and Steel.—The various branches of finished iron and steel present no new features of moment. Manufacturers generally are fairly well off for work, and further substantial orders are expected to be secured. Prices of some descriptions of material are inclined to stiffen, but actual advances have not occurred. Common iron bars are 12*l.*; iron rivets, 14*l.*; packing (parallel), 8*l.* 10*s.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.* 10*s.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, and joists, 10*l.*; heavy steel rails, 9*l.* 10*s.*; fish plates, 13*l.*; and galvanised corrugated sheets, 18*l.* 15*s.*

INDIAN TRADE WITH FOREIGN COUNTRIES.—According to the Department of Overseas Trade, the share of the United Kingdom in Indian imports fell from 61·5 per cent. in October, 1922, to 53·0 per cent. in October, 1923, while in exports, her share rose from 28·8 to 31·2 per cent. The shares of Germany, Japan, and the United States during October, 1923, were respectively 4·6, 6·0 and 4·0 per cent. in the case of imports, and 5·8, 4·5 and 10·4 per cent. in that of exports.

CONTRACTS.—Messrs. Vickers, Limited, Barrow-in-Furness, have recently received an order for Japanese owners for two marine heavy oil engines of 600 brake horse-power, to be repeats of the engine recently delivered to the order of their associates, Messrs. Mitsubishi Shoji Kaisha, Limited, Cory Buildings, 117, Fenchurch-street, London, E.C. 3. These engines are of the four-stroke cycle crosshead type with six cylinders 18¼ in. diameter by 27-in. stroke, and easily develop the required power at 150 r.p.m.

MESSRS. J. H. DALLMEYER'S SPEED CAMERA: ERRATUM.—We owe an apology to Messrs. J. H. Dallmeyer, Limited, for some very regrettable, though obvious, misprints in our notice of their exhibits at the Physical and Optical Societies' Exhibition, on page 20 of last week's issue. The name of the firm was misspelt in our reference to their kinematograph demonstration of the manufacture of a photographic lens, and the aperture of the Dallmeyer pentac lens of their speed camera, which we hope to describe in detail, was given as $f/29$, instead of 2·9.

STANDARD SPECIFICATION FOR STEEL CONDUITS, &C.—The British Engineering Standards Association has just issued a revised edition of the "Standard Specification for Steel Conduits for Electric Wiring," which was first issued in 1906 and subsequently revised in 1910. We notice that the current specification covers conduits of two additional diameters, viz., ¾ in. and 2½ in., and that, in the case of conduits of over 1 in. in diameter, the screw threads have been slightly shortened. In other respects the specifications for conduits are unaltered, but a comprehensive range of standards for conduit fittings has been included, and particulars are given of tests applicable to the materials used in the manufacture of both conduits and fittings. Copies of the publication, which is numbered 31—1923, may be obtained from the Publications Department of the British Engineering Standards Association, 28, Victoria-street, London, price 1*s.* 2*d.*, post free.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Although most of the Scottish steel works made a start this week on the conclusion of the New Year holidays, there is little stir in business circles yet. The prospects are fairly good for a revival of trade in a small way, but many hold the opinion that little or no real confidence will be noticeable in dealings of any kind until the political horizon becomes clearer both at home and abroad. Quite a fair number of inquiries are now in the market, and others are understood to be coming along soon. For the present, however, orders on hand ensure that a percentage of plant will be kept running steadily for a month or two. The start this week was fairly satisfactory, and as the shipyards gradually absorb their unemployed, the outlook in the steel trade will steadily get better. Quotations are firm all round.

Malleable Iron Trade.—There is little to report in connection with the West of Scotland malleable iron trade this week. Works have restarted, but most of them are able to undertake more orders than are now booked. These will, nevertheless, keep the wheels running for the present, and as inquiries are fairly good, the prospects of better times are very probable.

Scottish Pig-Iron Trade.—Work has now been resumed in the various pig-iron works, and quite a good start is general. Bookings all round are fairly good and inquiries point to better times ahead than has existed for months back. Both hematite and foundry grades of iron keep firm and an upward price move would not be surprising.

Shipments of Scottish Pig-Iron.—The shipments of Scottish pig-iron for the week ending last Saturday, January 5, from Glasgow Harbour, amounted to 830 tons. Of the total, 810 tons went overseas and 20 tons coastwise. For the corresponding week last year, the figures were 1,177 tons foreign and 42 tons coastwise, making a total shipment of 1,219 tons.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Night working in connection with the loading of coal cargoes has again been suspended at the Cardiff, Penarth and Barry docks, despite the recommendation of the Court of Inquiry, acting as a conciliation committee, that the third shift should be continued until January 19, pending conferences for the adjustment of the tippers and trimmers' rates of pay. The Court also found that the third shift was necessary in the interests of the trade of the district. The tippers, however, decided to terminate the third shift, and as a result the coal trimmers were automatically unable to work by weight. The tippers went even further, and intimated that if the Great Western Railway endeavoured to defeat their object by working the tips on the third shift they (the tippers) would withdraw their labour on the two day-shifts. At the other ports of Newport, Swansea and Port Talbot work is proceeding as usual. The employers have expressed strong resentment against the conduct of the men in refusing to carry out the recommendations of the conciliation committee. The temporary suspension of night working is likely to be followed by dock congestion and irregular working at the collieries because of the consequent delay created in returning empty wagons. Already about 100 tippers, who were taken on to work the extra shift, have been given provisional dismissal notices, and unless night work is resumed there is little doubt that many other men indirectly employed in providing coal for shipment by night will be dismissed. Colliery workers, too, are in a restive mood, and the outlook is threatening. A ballot is being taken on the question of whether the national agreement shall be ended. The men have been advised by their leaders to vote for its termination, but no practical suggestion is made as to what is to take the place of the present agreement, under which the men are guaranteed a minimum wage with the largest share in any surplus.

Iron and Steel.—Exports of iron and steel goods from South Wales last week amounted to 23,430 tons, shipments of tin and terne plates totalling 11,956 tons, compared with 301 tons in the previous week; blackplates and sheets, 6,728 tons, against 2,356 tons; galvanised sheets, 1,925 tons, against 1,850 tons, and other iron and steel goods, 2,822 tons, against 279 tons.

ACTIVATED CARBON FROM LIGNITE.—The activated carbons used for special reactions and for the absorption of vapours, *e.g.*, of benzene from coal gas, being expensive Franz Fischer and C. Zerbe, of the Carbon Research Institute at Mülheim-on-the-Ruhr, have examined various lignites as to their suitability for this purpose. A lignite from the Westerwald, which resembled partly charred wooden logs, proving especially suitable, nearly as good as charcoal, they tried other lignites of woody character. Coking them at various temperatures, they found high-coking temperatures of about 900 deg. C. profitable; when the temperature rose too high, there was an appreciable loss of material, owing to partial combustion. The benzene is generally expelled from the absorbing carbon afterwards by superheated steam at 180 deg. C., or less; in that case the carbon has to be dried again. Instead of this extraction, Fischer (*Brennstoffchemie*, December 1) passes hot coal gas through the carbon, condenses the expelled benzene by cooling, and uses the gas again for extraction. The clogged impure coke is finally as good a fuel as it had originally been.

NOTICES OF MEETINGS.

INSTITUTION OF MECHANICAL ENGINEERS.—To-day, January 11, at 7 p.m., Informal Meeting. A demonstration will be given of the following Cinematograph Films: "The Napier-Lion Aero Engine"; "The Citroen-Kegresse Car."—Friday, January 18, at 7 p.m., Informal Meeting. Subject for discussion, "British Locomotive Practice and Performance" (continued from November 2, 1923), to be introduced by Mr. R. E. L. Mannsell, C.B.E.; Sir Henry Fowler, K.B.E., in the Chair.

THE INSTITUTE OF METALS: SHEFFIELD LOCAL SECTION.—Friday, January 11, at 7.45 p.m., in the Albany Hotel, Fargate. Conjoint meeting with the Institution of Britih Foundrymen. Paper on "Influence of Casting Temperature on the Physical Properties of Metals," by Mr. F. H. Hurren.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, January 11, at 7.30 p.m. at 39, Victoria-street, S.W. 1. Paper "Concrete Engineering," by Mr. C. O. Mourant, M.I.Struct.E.—Wednesday, January 16, at the Royal Society of Arts, John Street, Adelphi, at 7.30. Presidential Address by Sir J. Fortescue, Flannery, Bart., "Marine Propulsion during Fifty Years."—Friday, January 18, at 39, Victoria-street, at 7.30. Lecturette: "The Liability of Employers in respect of Personal Injuries to their Workmen," by G. F. Tyler.—Saturday, 19 January, at 2 o'clock, Visit to the County Hall, Westminster Bridge.

THE INSTITUTE OF BRITISH FOUNDRYMEN: LANCASHIRE BRANCH.—Saturday, January 12, at 4 p.m., in the College of Technology, Sackville Street, Manchester. Paper "The Practical Value of Modern Non-Ferrous Alloys," by S. F. Barclay, D.Sc., M.Inst.C.E.

THE INSTITUTE OF METALS: SCOTTISH LOCAL SECTION.—Monday, January 14, at 7.30 p.m. in the rooms of the Institution of Engineers and Shipbuilders in Scotland, 39, Elmbank-crescent, Glasgow. Open discussion.

THE INSTITUTE OF MARINE ENGINEERS.—Tuesday, January 15, at 6.30 p.m., at 85, The Minories, Tower Hill, E.1. Adjourned discussion on "Superheating."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, January 15, at 6 p.m., at Great George Street, S.W. 1. Paper to be submitted for further discussion: "An Account of an Examination of the Menai Suspension Bridge," by Mr. Henry Tudsbery Tudsbery, M.C., M.Inst.C.E., and Mr. Alec Robert Gibbs, Assoc. M.Inst.C.E. Wednesday, January 16, at 7 p.m. Informal Meeting. Subject for discussion:—"The Practical Testing of Steam Boilers," by Mr. Robert Hodson Parsons, Assoc. M.Inst.C.E.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND.—Tuesday, January 15, at 7.30 p.m., in the Rankine Hall, 39, Elmbank-crescent, Glasgow. Paper on "Some Limiting Conditions of External Combustion Engine Efficiency," by Mr. James G. Weir, C.M.G., C.B.E.

INSTITUTE OF TRANSPORT.—Tuesday, January 15, Mr. A. F. Bound (Member) will deliver a lecture on "Railway Signalling and its Development" in the Lecture Theatre of the Institution of Electrical Engineers, Victoria Embankment, at 5.30 p.m.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, January 16, at 7.30 p.m., at 49, Cromwell-road, South Kensington. Presentation of the Symons Medal, awarded to Professor Takematsu Okada, Director, Central Meteorological Observatory, Tokyo. Address on "Reflections on various Subjects, including Meteorology and Sunspots," by Charles Chree, D.Sc., LL.D., F.R.S.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, January 16, at 2.30 p.m., in Lecture Theatre, E. 17, The College of Technology, Sackville-street, Manchester. To receive and discuss the following papers:—(*a*) "Further Contributions to the Study of the Effect of Alumina in Glass," by Violet Dimbleby, B.Sc., S. English, M.Sc., F. W. Hodkin, B.Sc., and Professor W. E. S. Turner, D.Sc. (*b*) "The Production of Colourless Glass in Tank Furnaces, with Special Reference to the Use of Selenium. Part III, The Influence of Light and Temperature on the Change of Colour," by A. Cousen, B.Sc., and Professor W. E. S. Turner, D.Sc. Discussions on:—(*a*) "Specifications for Glass," based on the paper read at the London meeting on December 12, 1923, by Professor W. E. S. Turner, D.Sc. (*b*) "The Production of Colourless Glass in Tank Furnaces, with Special Reference to the Use of Selenium, Part II."

THE INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Thursday, January 17, at The University, Edmund Street, Birmingham, in the Latin Theatre, at 6.0 p.m. Mr. A. W. Nash, M.I.Mech.E., M.I.P.T., lecturer in Oil Mining at the University of Birmingham, will read a paper on "Various Methods employed in Boring for Oil in the Petroleum Industry."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, January 17, at 6 p.m. "Electric Passenger Lifts," by H. Marryat, Member.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—Friday, January 18, at 7.15 p.m., in the Metallurgical Department, University College, Singleton Park. Paper on "Annealing of Non-Ferrous Metals," by Captain L. Taverner, A.R.S.M.

ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 18, at 9 o'clock, a discourse will be delivered by Professor H. E. Armstrong, LL.D., F.R.S., on "The Scientific Work of Professor Sir James Dewar, LL.D., D.Sc., F.R.S." Afternoon lectures next week: Thursday, January 17, W. Sickert, on "Straws from Cumberland Market (Lecture I)," 5.15 p.m.; Saturday, January 19, R. Reynolds, A.G.S.M., on "The Mechanical Reproduction of Music" (with musical illustrations), 3 p.m.

UNIVERSITY COLLEGE OF SOUTHAMPTON ENGINEERING SOCIETY.—Friday, January 18, at 7.30 p.m., at the University College, Southampton. Mr. John Smith, M.I.N.A., will read a paper on "Wireless Telephony." Mr. Tom Thornycroft will occupy the chair.

ROYAL SOCIETY OF ARTS; INDIAN SECTION.—Friday, January 18, at 4.30 p.m. "The Survey of India," by Colonel H. L. Crosthwait, C.I.E., R.E., retired, late Superintendent, Survey of India. Sir Thomas H. Holland, K.C.S.I., K.C.I.E., will preside.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Friday, January 18, at Bolbec Hall, Newcastle-upon-Tyne. "Influence of Propelling Machinery on the Running Costs of Ships," by W. G. A. Perring.

THE INSTITUTION OF ENGINEERING INSPECTION.—Friday, January 18, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C. 2. Lecture: "Reminiscences of Railway Work Overseas," by Mr. Frank Grove, O.B.E., M.Inst.C.E..

BRIDGES FOR NEW ZEALAND.—H.M. Trade Commissioner at Wellington has forwarded to the Department of Overseas Trade specifications and drawings relative to a call for tenders by the Public Works Tender Board, Wellington, for the supply of 63 deck plates girder spans of various dimensions. Tenders close with the secretary, Public Works Tender Board, Wellington, on February 26. Further particulars can be obtained by United Kingdom firms on application to the Department of Overseas Trade, quoting reference 12,838/E.D./E.C. (2).

SPITZBERGEN COAL.—The coal mining industry at Spitzbergen, on the whole, has not come up to the expectations with which it was started, but the Swediah undertaking, the Spitzbergen Company, is still carrying on, and prospects are apparently improving. During the financial year, from July 1, 1922, to June 30, 1923, the production amounted to 80,706 tons, in addition to which 52,965 tons were available from the previous year. The quality of the coal is improving, and tests with the coal worked during this last year prove it to equal the best Yorkshire. Some 200 workmen are wintering in Spitzbergen.

TAX-COLLECTING COST IN THE UNITED STATES.—We read in *The Valve World*, Chicago, that the cost to the tax-payer and to the public at large of tax-collecting by the Federal Government is at least 20 per cent. of the total amount collected. This is considered by the journal to be a conservative statement, since Government cost figures seldom tell the whole story; they do not go far enough and do not include all the cost to the public. For example, in giving the cost of collecting the income-tax the Government figures neither include the very considerable cost to the taxpayers of preparing the tax returns, nor the cost to the Government of handling returns after the taxes have been collected.

ITALIAN TORPEDOES.—The Italian torpedo factory—the Silurifico Italiano of Naples—has recently been experimenting with a new type of torpedo which is claimed to have a minimum speed of 48 knots up to 3,000 metres, and of 27 knots up to 15,000 metres. Its depth can be regulated up to 12 metres. The diameter of the new weapon is 533 mm. Its speed can be regulated, and the maximum rate at which it is capable of travelling through the water is said to be 53 knots. The invention extends to the permanent fittings of the torpedo, which is "set" for distance, speed, and depth, whilst actually in the tube, and can therefore be adjusted to the data available at the moment of firing. Its inventor is Francesco Schmid, one of the technical directors of the Silurifico Italiano.

GERMAN POTASH AND BUSINESS METHODS.—We can certainly learn a lesson of persistent effort from those who would sell foreign potash in the United States, says *Industrial and Engineering Chemistry*, Washington. We are all familiar, says our contemporary, with the various schemes by which it was sought to convince the farmer that without imported potash he must soon go out of business, and the only man we ever saw listed as a propagandist in a telephone directory was one who devoted his entire time to the interest of German potash. A magazine has recently been issued; it is supposed to be in the interests of the farmer and the working man, but turns out to be a straight advertisement for German potash. This booklet, "Better Crops, the Pocket Book of Agriculture," published by the Potash Importing Corporation of America, is apparently a harmless little handbook got out in convenient form for the farmer, but in reality is nothing more nor less than an advertising proposition for German potash, containing as it does such statements as: ". . . Therefore, if the course of potash in the complete fertiliser is unknown or in doubt, and if the percentage of potash is small, it is important to apply additional potash in the form of German Double Manure Salt, to furnish both the potash and magnesium requirement." Even the advertisements throughout the booklet concern the imported material directly or are those of companies listed as sources of "genuine German potash." Of course, concludes our contemporary, we can take no exception to anyone's advertising his wares for sale, but we prefer to have it done without camouflage, so that those who read may know exactly the source of their information.

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(*For Description, see Page* 42.)

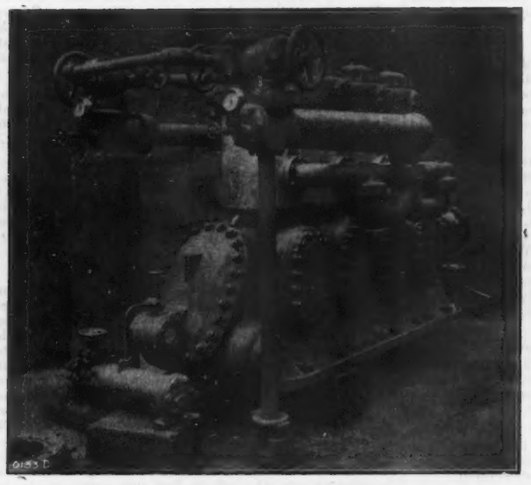

FIG. 7.

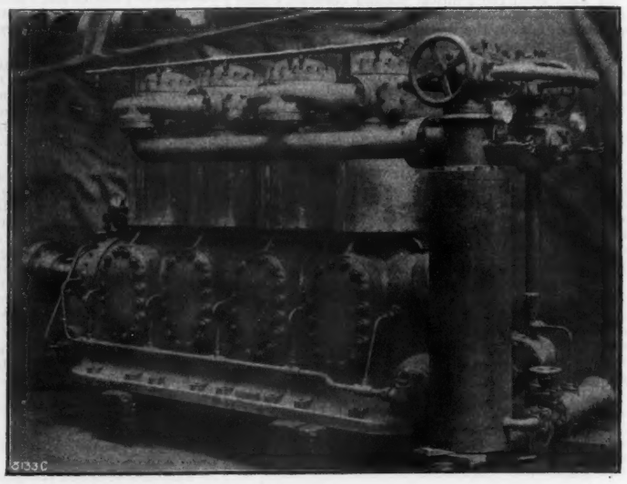

FIG. 8.

FIGS. 7 AND 8. FOUR-CYLINDER 40-TON REFRIGERATING MACHINE.

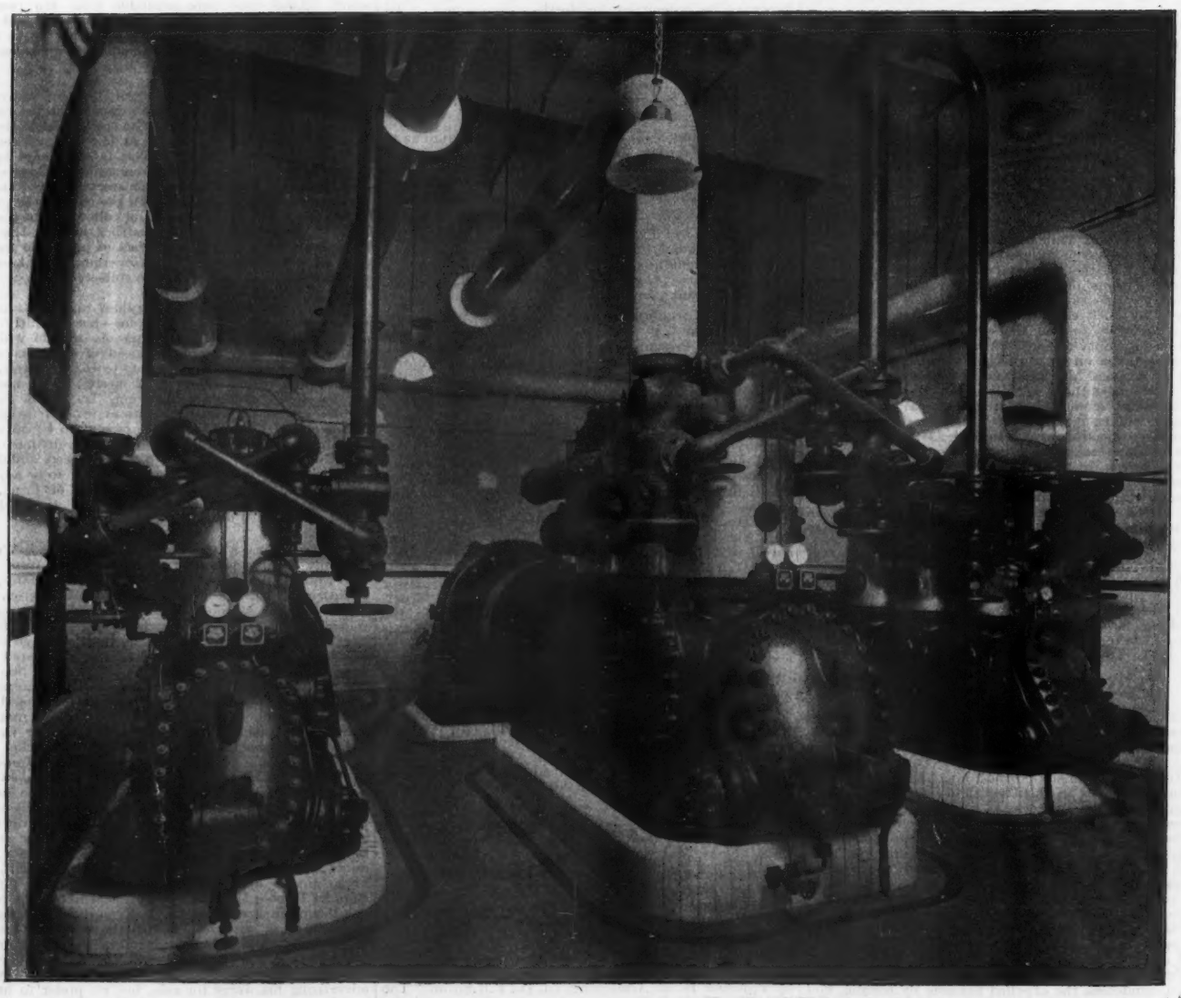

FIG. 9. THREE HUNDRED TON REFRIGERATING INSTALLATION AT BLACKFRIARS COLD STORES.

THE CONSTRUCTION OF THE KING GEO[illegible]E'S

MR. J. MACGLASHAN, M.INST.C.E., CHIEF ENGINEER OF [illegible]OMMISSI

(For Des[illegible] Page 3

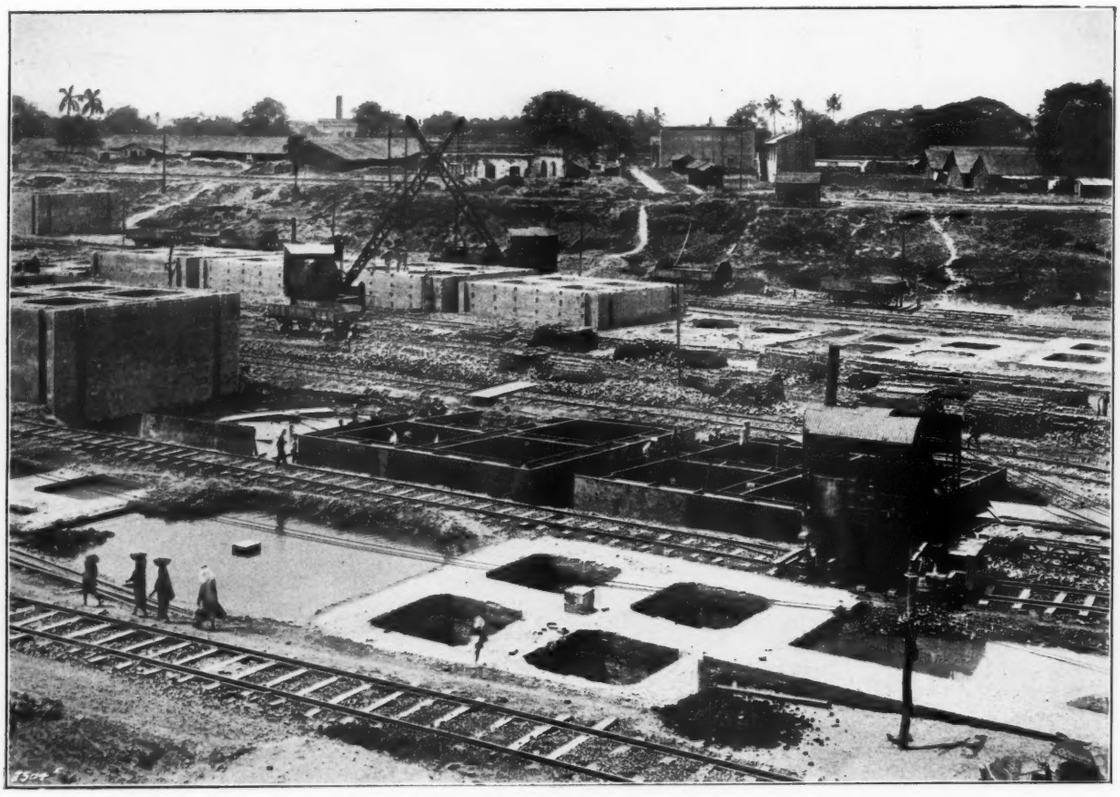

FIG. 9. WELL CURBS BEING ASSEMBLED IN POSITION.

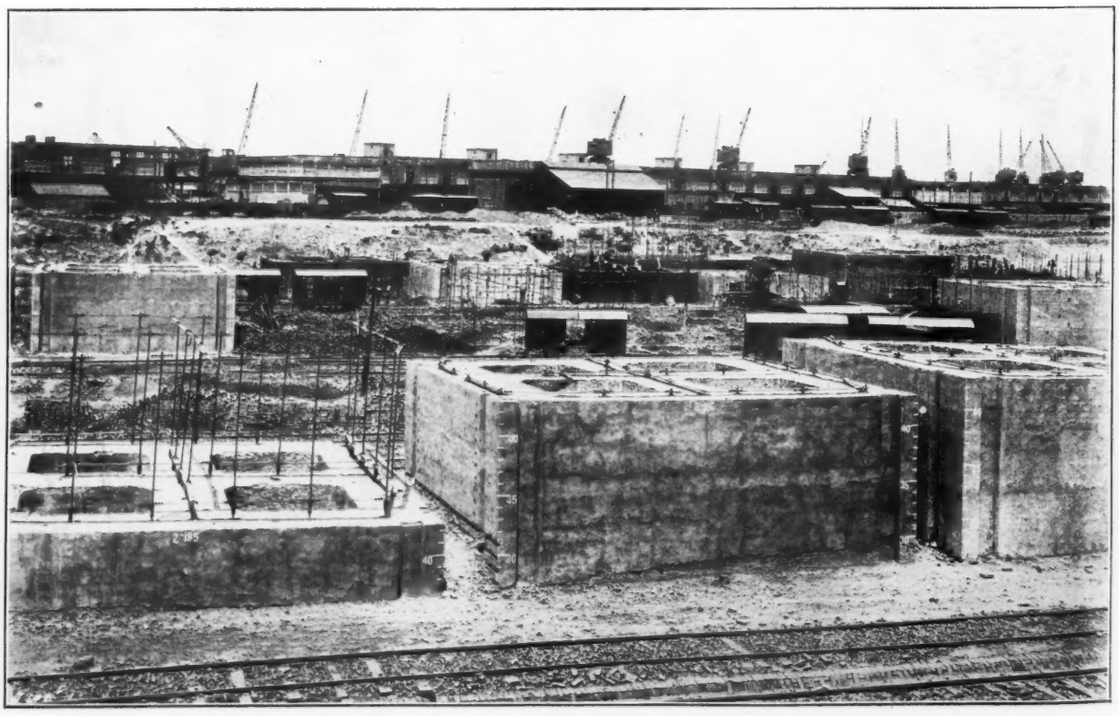

FIG. 11. MONOLITHS BEING SUNK; REINFORCEMENT IN POSITION.

GEGE'S DOCK OF THE PORT OF CALCUTTA.

EER OF [illegible]OMMISSION OF THE PORT OF CALCUTTA, ENGINEER.

(For Description, *see Page 37.*)

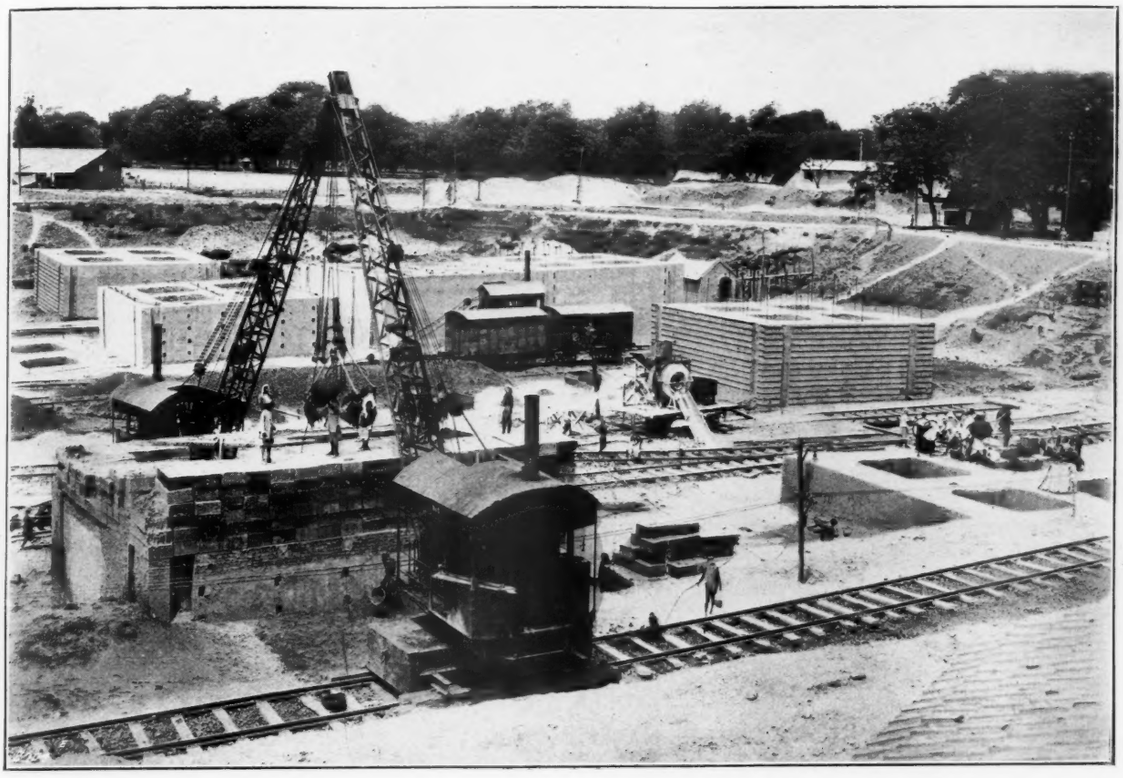

FIG. 10. VIEW SHOWING MONOLITH LOADED, AND EXCAVATION PROCEEDING IN SHAFTS BY MEANS OF GRABS.

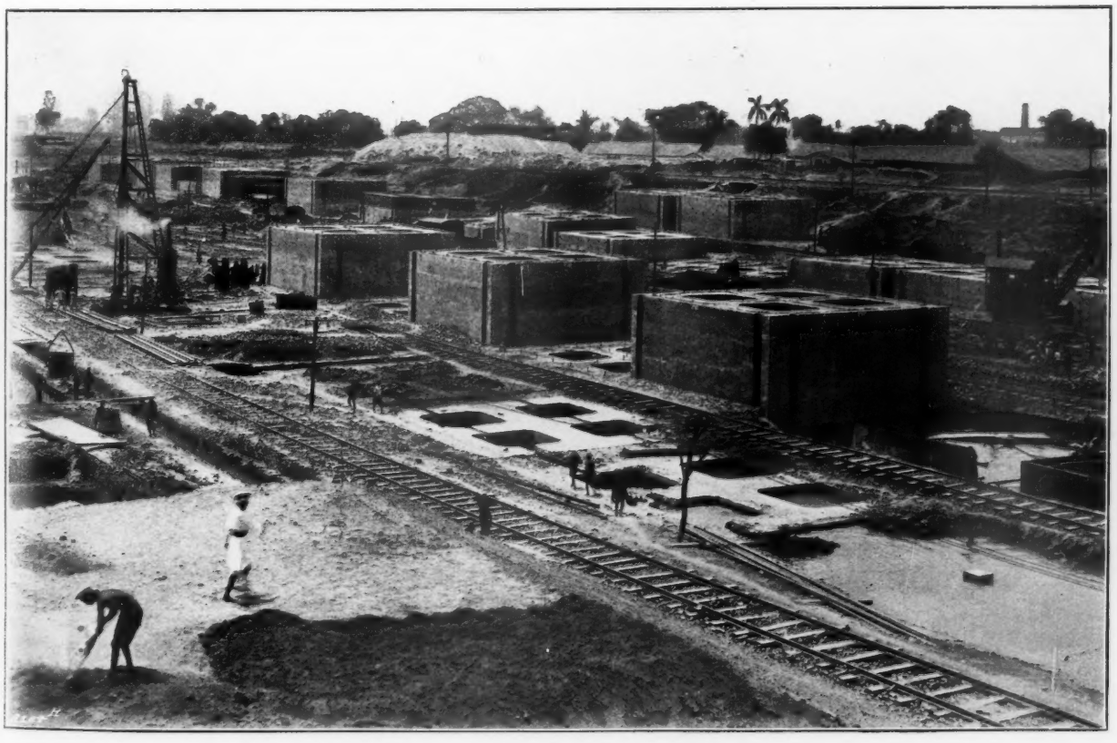

FIG. 12. VIEW SHOWING, IN FOREGROUND, MONOLITHS SUNK TO FINAL LEVEL.

ENGINEERING.

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CONTENTS.

	PAGE
The Elements of the Lanchester-Prandtl Theory of Aeroplane Lift and Drag (*Illus.*)	35
Building in Earthquake Countries	37
The Extension of the Port of Calcutta (*Illus.*)	37
The Intensity of Rainfall (*Illus.*)	40
Refrigerating Plant with High-Speed Ammonia Compressors (*Illus.*)	42
Industrial Notes	43
Small Turbo-Generator Lighting Set for Outdoor Use (*Illus.*)	44
Year-Books and Annuals	44
Notes on New Books	45
The Müller X-Ray Spectrograph (*Illus.*)	46
Letter to the Editor.—"Binary Fluid Turbines"	47
Notes from South Yorkshire	48
Notes from Cleveland and the Northern Counties	48
Notes from the North	49
Notes from the South-West	49
Notices of Meetings	49
The Electrification of Main Line Railways	51
German and American Competition in South Africa	52
Overhead Lines	52
The Loss of the "Dixmude"	53
The Physical and Optical Societies' Exhibition (*Illus.*)	54
Notes	56
Literature	57
Books Received	58
Small Planing Machine for Hand or Power Operation (*Illus.*)	58
Water-Cooled Aero-Engines (*Illus.*)	59
ENGINEERING Patent Record (*Illus.*)	63

Two-Page Plate.—THE CONSTRUCTION OF THE KING GEORGE'S DOCK OF THE PORT OF CALCUTTA.

ENGINEERING.

FRIDAY, JANUARY 11, 1924.

THE ELECTRIFICATION OF MAIN LINE RAILWAYS.

THERE are many people who regard the electrification of our main line railways as something which is bound to occur in time, and which, indeed, would be well under way at present were it not for the conservatism of our railway engineers. Very few things, however, occur of themselves, whether for good or evil, and electrification is not one of them. If it does come about, it will be an intentional change resolved on and carried through for reasons which appear sufficient to those upon whom the responsibility rests. It is quite wrong to prejudice the case by assuming that there is anything necessarily more "scientific" or otherwise commendable in hauling trains by electricity rather than by steam locomotives. The fact that electric traction was developed subsequently to steam traction is no proof that it will supersede it generally. The Duke of Wellington's comment on a newly invented steam-gun, namely, that it would be the best kind of gun in the world if gunpowder had never been discovered, is applicable, *mutatis mutandis* to many devices. Electric traction has certain fairly well defined fields in which it is pre-eminent, such as, for example, the operation of dense suburban traffic on underground railways, but for long distance main line haulage its superiority over steam, under the conditions which obtain in this country, has yet to be demonstrated. We do not maintain that it cannot be demonstrated, but merely state that this has not yet been done to the satisfaction of the men who have to be convinced, while the present disagreement amongst electrical enthusiasts as to the system upon which electrification should be carried out must be modified before their general propositions are accepted.

Any argument that main line electrification must be desirable in Great Britain because certain foreign countries have found it advisable to electrify some of their important lines is quite beside the point, and it is even more inept to believe when foreign practice differs from our own, that it is necessarily worthy of imitation. We need not be envious of flat-bottomed rails spiked direct to the sleepers, adequate as they may be in other countries, nor do we desire to increase our level crossings in proportion to our bridges, to abolish platforms, or to exchange our 60 miles-an-hour expresses for trains which run with less speed, punctuality or safety. These matters, of course, have nothing to do with electrification, but as our railway engineers have given us equipment and service at least equal to anything in the world, and better than most countries can show, it is not fair to assume that they have allowed themselves to be outclassed because the Scotch express still goes North every night with a steam locomotive at its head. It is nevertheless of interest to note what progress main line electrification is making in other countries, for circumstances are continually changing and a conclusion which was valid yesterday might be overthrown to-morrow by the emergence of new conditions.

So far as Europe is concerned, the greatest development of electrification is taking place in Italy, Switzerland and France. The Italian State Railways have an electrification programme of 2,800 route miles of which 420 miles had been completed in 1922. The Swiss Federal Railways expect to have over 600 miles electrified by 1924, and their programme provides for the electrification of 1,075 miles, or 60 per cent. of their total mileage by 1931. In France the greatest activity is in connection with the Midi Railway. A description of the work of electrification on this system was recently given before the Institution of Electrical Engineers in London by M. A. Bachellery, the engineer-in-chief. Within the next ten years nearly 2,000 miles of route will be electrified in the South of France, and according to the report of M. Sabouret to the last International Railway Congress, the P.L.M., the Midi, and the Paris-Orleans railways will have between them 5,000 miles of electrified line before twenty years have passed. Germany has about 780 miles wholly or partially electrified, and the United States something like double this mileage. No other countries have anything comparable with those we have referred to, although there are few which have not something in the way of electrification either to show or in contemplation.

A summary of the present state of railway electrification abroad was given on January 3 by Professor S. P. Smith, in a lecture before the Institution of Electrical Engineers, and this, following so closely upon M. Bachellery's paper, shows that a considerable interest is taken in the subject. Much of the matter of Dr. Smith's lecture had previously appeared in the form of articles in the Beama Journal, which we note now appears under the title of *World Power*, but its presentation to a wider audience was well justified. Focussing, as it did, the railway electrification throughout the world within a small compass. Dr. Smith's presentation of the facts brought out a good many considerations which deserve recognition, when the question of British main line electrification is under discussion. The activity of Swiss and Italian engineers in extending electrical operations is largely due to circumstances which have no parallel in this country. Neither of these countries possesses any coal mines, and their dependence upon other nations for fuel was brought home to them in an unmistakable manner during the war. Norway and Sweden found themselves in an almost equally unenviable position, and in all these countries there was aroused a determination to utilise their own resources as far as possible. Fortunately, they all possessed water-power in large quantities, and thus circumstances combined to bring about the development of large schemes of railway electrification. France, too, is a country which is very short of coal, and it is significant, although natural, that her southern railways, alongside which water-power is abundant, should be the first to adopt electric traction on a large scale.

That the scarcity of coal has been the determining factor in most European electrification schemes is amply borne out by evidence. In the report of the Swiss Federal Council on the financial condition of the Swiss railways, presented to the International Railway Commission in 1922, we read: "The electrification of the Federal railways is an economic necessity. . . . We must not for ever remain dependent on foreign countries which may withhold their coal, or at any rate dictate their prices without

consideration for us." Again, Mr. Ofverholm commenced his report on railway electrification in Scandinavia by the words "Sweden, Norway and Denmark have not the necessary quantity of home-produced coal . . . . In the first two countries railway electrification on a large scale has been contemplated in order to utilise water-power instead of depending on imported coal. In Denmark, owing to the lack of water-power, no such schemes are in existence." It is quite clear from these quotations that the coal question was foremost in the minds of those who adopted the policy of electrification in the countries mentioned. It is interesting to mention that in 1920, 30·5 per cent. of the coal burned in Switzerland came from England, 55·9 per cent. from America, and only 6·6 per cent. from Belgium, the Sarre or the Ruhr Valley. Germany is not so badly off for coal as the countries mentioned, but much of the Eastern coal is very poor and in Bavaria, where water-power is available, we have Dr. Smith's authority for saying that the decision to extend electric traction was hastened by the coal shortage subsequent to 1918.

We, in this country, have abundant coal but no hydro-electric power, so that the reason which influenced continental engineers most strongly in the development of electrification has no weight with us. It is, we think, quite fair to say that the electric operation of railways has always come about, not because of any idea of technical progress but rather because conditions under steam operation had become intolerable. The Underground system of London, the heavily loaded suburban systems in this and other countries are examples in which steam traction had reached its limitations. The change-over to electrical working is bound to go on in cases such as these, and we have instances very near home in which travellers would say that the change was already long overdue. It gives a higher average speed when stops are numerous, and enormously increases the effective capacity of the terminal stations, besides doing away with much smoke and dirt—so that a much heavier traffic can be handled with greater comfort. That electrifications pays, financially, under conditions such as those of dense suburban traffic is unquestionable, though even if it did not, it would have to be adopted if the passengers were to be moved in the time available.

The two great objections to main line elec rification in Great Britain are the heavy capital cost involved and the far-reaching consequences of any failure of the electric system. The former is by far the more serious, as there is no reason why the reliability of the power supply should not be equal to that of the lighting systems in which we have become accustomed to place perfect confidence. Nevertheless it is true that no conceivable accident could completely paralyse any section of a steam railway, whereas enormous inconvenience would be brought about by the cessation of the power supply to an electrified railway, even for a very short time. To justify electrification in this country one of three facts must be demonstrated. Either it must be shown that steam haulage is no longer adequate for the traffic to be carried, or that the railways could be operated more cheaply by electricity, or that electric working would result in such an increase of traffic as to earn the interest upon the capital expenditure entailed by the conversion. All of these matters can be made the subject of fairly precise estimates, and at any rate they can be determined with at least as high a degree of certainty as is considered sufficient for other commercial enterprises to be undertaken.

In making such estimates it is quite wrong to assume that the steam locomotive has reached its limits either of power or of economy. Turbine-driven locomotives are now being supplied under a firm contract that they will do the same work as engines of the ordinary type with half the fuel consumption of the latter. A British firm has now entered into arrangements for the construction of locomotives of this type, and if they prove as successful as there is reason to anticipate it is very doubtful whether there would be any saving in fuel by transferring its combustion from the fire boxes of individual locomotives to the furnaces of large central stations, when the electrical conversion and transmission losses are taken into account. The question of electrification of important lines in this country, however, is not to be settled by considerations of fuel economy alone, any more than it can be decided by the enthusiasm of electrical engineers on one hand, or the conservatism of established practice on the other. A close and continuous study of the conditions ought to be maintained, for as soon as ever there is a reasonable assurance that electric traction would be commercially practicable it should be adopted. Large schemes of electrification will certainly have to be carried out in the Overseas Dominions and in other parts of the world where water-power is available, and it would be of the utmost advantage to our manufacturers to be able to point out to possible clients, successfully working schemes on a large scale in this country. We cannot expect our railway companies to be philanthropists. It is their primary duty to operate their systems by the most economical means, but their secondary interest is certainly to assist the trade of the country, and anything they can do to develop a healthy business at home in electric locomotives and equipment will both benefit our export trade and prevent their own dependence upon foreign experience and material at some future time.

GERMAN AND AMERICAN COMPETITION IN SOUTH AFRICA.

Now that South African trade has passed through the period of depression which followed the post-war boom, an opportunity is afforded to study the extent of the participation of foreign countries in this market. The after-effects of the European War have affected, to very different extents and in different ways, the many countries with which South Africa trades, and the effects of this, it might be anticipated, would be shown in the returns of exports and imports. For the study of these and similar matters a great amount of information is provided in the regular series of reports issued by the Department of Overseas Trade. There can be no doubt of the service rendered to the trading community by their publication, and the recently-issued one on "The Economic Position of South Africa, July 1923," prepared by Mr. W. G. Wickham, is a very representative example. It contains information not only on total imports and exports, but also relating to the trade done in particular classes of goods. The detailed statements which are given in it make possible a complete examination of the trading relations of South Africa with other countries, and since it is a common belief, frequently stated, that the Americans and Germans are making great headway in this market, we propose to examine the figures and other particulars regarding their share of the total business done.

The first impression created by the study of the figures is the manner in which Germany is recovering her trade with South Africa. In 1919 the importation of goods from that source only amounted to a few thousand pounds in value. This was increased to over one million pounds in 1921, and a further extension to over two and a-half millions was shown in 1922. The exports to Germany from South Africa—which, however, do not include any goods resold to Germany from the United Kingdom and other European countries—show similar expansion, and have reached the figure of 2,875,000*l.* For the same period American trade has suffered a decline after a temporary and partial recovery in the boom year of 1920. The figures for American imports were 11,000,000*l.* in 1919, 17,000,000*l.* in 1920, 8,000,000*l.* in 1921, and fell to 5,683,000*l.* in 1922. As far as Great Britain is concerned the share, apart from Government imports, amounted to 46 per cent. of the total in 1919, but has since remained steady at about 55 per cent., which is slightly higher than in 1913. The figures given for German trade seem substantial, but amount actually to only 5¾ per cent., which is much lower than the 9 per cent. of pre-war days. It is interesting to note that the combined total of imports from America and Germany have remained practically equal to the pre-war value of 18⅛ per cent.

German competition has been shown most keenly in all classes of domestic ware. In the aluminium utensil market German goods account for five-sixths of the total trade, and somewhat similar characteristics are apparent in the trade in enamel ware. When the returns for agricultural machinery are reviewed it is apparent that German competition is keenest in the market for dairy utensils and ploughs. The old German position in fencing wire and other wire products has been re-established. Germany also supplies a large proportion of the iron and steel requirements of the Dominion. In this field she has two-fifths of the trade in rails, one-quarter of the market for plates and supplies one-half of the importation of iron and steel pipes. A markedly reduced demand for her general machinery and electrical goods is, however, manifest.

The chief import obtained from America is mineral oil and its associated products. Last year American machinery and electrical goods amounted to 1,690,000*l.*, but this report shows a reduction to 583,000*l.* Almost similar proportionate reductions are seen in the returns for iron and steel. Belts for conveyors in the gold mines and also for works driving seem to be procured from the United States to a greater extent than should be the case, and rubber hose is another example in which the trade in British products is not very successful. There are markets such as that of typewriters, where America had practically a monopoly but is now being hit by competition. Britain now holds 20 per cent. of the typewriter market and Germany 13 per cent. The American share of the trade in clocks and watches has now mostly gone to Germany and Switzerland. Little progress has been made with the importation of motor cars produced by British manufacturers as prices generally rule too high for the market. Although the Government importation for the railways was much less than in the period covered by the previous report it is satisfactory to note that of the total of 4,185,000*l.* only 6 per cent. was accounted for by non-British products. Items received from outside the Empire were American rails, Swedish telegraph and telephone products, German and American locomotives, rolling stock and electric cables. There is, from the information given in Mr. Wickham's report, no reason for dissatisfaction with the position of British trade in the Dominion markets. The pre-war percentages are well maintained. There are individual articles of commerce, however, in the markets for which improvement could be effected if endeavours were made to study the requirements and local conditions more closely.

OVERHEAD LINES.

THE use of overhead lines for electrical transmission and distribution is extending in this country, and the total of all such installations now amounts to quite a respectable figure. It is only in quite recent years, however, that a realisation of the possibilities in this direction has become at all common. In the past it was quite usual to hear that overhead transmission lines were unsightly, although in what way they are more unsightly than some of the heavily-loaded pole lines put up by the Post Office, which are endured without protest, we are unable to say. There was also an idea in the past that such lines were dangerous to the public and the opposition to any development of this kind of work which was displayed by the Board of Trade can have had no other basis. We have heard a distinguished late Electrical Adviser to the Board of Trade state that the Board at no time had any objection to overhead lines and never opposed them, but we are afraid this statement hardly falls in with the experience of those who were attempting to extend electrical networks.

A development can be opposed, by an over-ruling authority either by forbidding it, or by making the conditions of its installation so onerous that no one can afford to utilise it. A state of affairs not greatly different from this latter condition represented the official method of dealing with overhead mains in earlier days, and even the existing Board of Trade rules do much to discourage work of the kind. The limiting span for low-tension mains is for instance specified to be 200 ft. There appears to be no reason for this other than to increase the number of poles and put up the cost of the line, and it is

satisfactory to see that the new regulations which have been prescribed by the Electricity Commissioners say nothing at all about spans. The safety of the public is ensured by specifying that poles and the lines they carry shall be strong enough for the stresses that come on them, and not by imposing limiting conditions which by putting up expense unnecessarily in one direction may introduce a tendency to save it in other and perhaps undesirable ways.

Although we wish, and hope, to see a great extension of overhead lines in this country, it is not on account of any affection for overhead lines *per se*, as against underground cables. Electrical development is retarded when any item which is necessary for its extension is made more expensive than it need be, and there are many small towns and country districts which offer profitable fields for electricity supply, providing power can be delivered there at a reasonable price. The cost of mains is frequently, or usually, one of the determining figures in such price, and overhead mains as against underground cables will in many cases make the difference between possibility and impossibility. At the same time the overhead line must be as cheap as possible consistent with reliability, and because of the assistance they will afford in this direction the new regulations are to be welcomed. As an example, the factor of safety of wood poles has been reduced to 3·5 as compared with 10 of the Board of Trade rules. As the new regulations have been prepared in conjunction with a committee of the Institution of Electrical Engineers under the chairmanship of Mr. E. V. Twiss, one may take it that safety has not been sacrificed to cheapness. The question of the stresses involved has been gone into very carefully, and the regulations for instance take account of ice-loading on the lines which was ignored in the old rules.

The question of span is a quite important one, as the fewer the poles the fewer points of weakness in the line. A longer span, while reducing the number of insulators necessarily involves a heavier and more expensive type of pole, and the cheapest overall arrangement for an individaul case is necessarily a matter for individual investigation. The advantages of a designer not being tied to any minimum span are very great. Mr. W. E. Highfield, the president, at a meeting of the National Association of Supervising Electricians, last Tuesday evening, expressed a preference for lattice work steel poles with long spans, and there is no doubt but that such an arrangement would in many cases prove both the most efficient and cheapest. No rules can be laid down, however, as questions of transport of the poles may in many cases lay a veto on the heavier steel pole. This condition will also frequently be a determining factor when reinforced concrete poles are under consideration.

The occasion of Mr. Highfield's remark was a paper by Mr. S. Austen Stigant, on the subject of medium and low-pressure overhead lines. Mr. Stigant dealt with the various detail items entering into an overhead line, and gave a review of current practice which clearly illustrated that a very good class of work is being put into British pole lines. We would not plead for any other class of work, but it is well to realise that it is possible to make too good a job of a line running out into a country district which it is hoped to develop. Too good a job means too expensive a job, so that either current will not be sold at the far end of the line so cheaply as it otherwise might be, or the line will not be built at all. Either procedure hampers electrical development. A cheaper line may not be quite so reliable as a more expensive one, but in many cases the problem resolves itself into a question of a cheap line, or no line, and there are few districts which would not prefer an electricity supply with a possibility of failure for, say, one day in a year, to no electricity supply at all.

THE LOSS OF THE "DIXMUDE."

THE loss of the French airship Dixmude with the whole of her passengers and crew, some 54 in number, will increase the distrust of the general public in this method of transportation. Since the disaster to R. 38 in the autumn of 1921 there has been little activity, so far as rigid airships are concerned, either in this or any other country. There have, however, been several accidents to other types of airships in Italy, the United States and Japan.

The Dixmude, built by the German Government as L. 72, was completed after the Armistice and allocated to the French Government. An airship —L. 71—of the same class was taken over by the British Government but is understood to have been dismantled, having carried out little or no flying since she was received at Pulham. Both of these ships were intended for war purposes and embodied all those modifications and improvements, which the Germans, with their extensive experience with the type had found necessary or desirable.

These latest products of the Zeppelin designers were nearly 750 ft. long and 80 ft. diameter, displacing some 2½ million cub. ft. and having a gross lift of 73 tons. The disposable lift was 64 per cent. of the gross, the highest figure yet attained in this particular type, and indicating a high "ceiling" sufficient to take the ship beyond the range of anti-aircraft guns. Six engines each of 260 h.p. were carried in separate gondolas, and designed to give a maximum speed of about 70 m.p.h. The petrol stowage was stated to be sufficient to give a radius of action of 11,000 miles at economical speed.

The Dixmude was stationed at Toulon and was intended by the French to be one means of communication with the North African possessions. Already she had made one voyage and is said to have encountered a severe gale without sustaining any damage, although the gondolas and envelope were on landing found to have accumulated 9 tons of rain water. On her last voyage she left Toulon at 6.30 a.m. on Tuesday, December 18, and pursuing a nearly southernly course passed over Bizerta and was reported at Insalah in the Sahara at 4.30 p.m. on the Wednesday. The direct distance from Toulon to Insalah is about 1,200 miles, and allowing for the direction pursued by the airship the speed over the ground would be about 38 m.p.h. or close to the most economical speed. At 1.30 a.m. on the Thursday she was reported west of Ouargla, 310 miles north of Insalah, an indication she was cruising at the same speed and returning. Here she received a warning that a storm was rising. At 8.30 a.m. on the same day she reached Tougart, about 100 miles north of Ouargla and proceeded to cruise in the Biskra region. On Friday she was reported as 70 miles north of Tougart. This was at 8 p.m. The next day, Saturday, she was over the Gulf of Gabes, about 250 miles east of Tougart, and sent out signals for help stating she was in a heavy storm and was short of petrol. Nothing more was heard from the vessel, but on the Thursday following, the body of the commanding officer was found by fishermen on the southern coast of Sicily. There is little doubt the airship was destroyed either on the afternoon of the 22nd or the morning of the 23rd, a very heavy storm being experienced in the Southern Mediterranean at this time. According to one report the Dixmude set out with sufficient petrol for a 72 hours voyage, and if this is correct she had but barely sufficient for the flight to Insalah and the return. The delay in returning after receiving the warning message and her continued flight in the Biskra region would appear to indicate some difficulty in navigation or defect in her machinery.

The French Government are to hold an inquiry into the circumstances of the loss, but with the disappearance of the passengers and crew and also of the wreck it is difficult to see how a definite conclusion can be arrived at. Dredging operations are being carried out off the coast of Sicily in the hope of recovering the wreck, but even assuming the operations are successful, the tangled mass of wires and girders which usually result from such accidents makes it extremely difficult to arrive at the primary cause of the disaster.

The Paris press, which is naturally very disturbed over the grievous loss, has printed a report of the late commanding officer, in which on bringing over the airship from Germany he stated she was very lightly built, and although for war purposes some risk in this respect had to be accepted, yet in peace time some alteration was required. It has not transpired if any strengthening was introduced. According to other reports her construction was hastily undertaken under war conditions, and as a consequence the workmanship was not as good as might be expected in normal times. There is probably little ground for such a report, for all who have examined German war productions have been generally impressed with the standard of workmanship. But further than this the vessel had been in French hands for over three years, sufficient for a thorough overhaul, and for the remedy of any defects which might have been brought to light.

The advocates of the rigid airship do not appear to be dismayed by the loss of the Dixmude, and both in France and this country they urge that its development shall proceed. They explain the loss of the Dixmude primarily by its lightness of construction, which although necessary in a vessel intended for use in war, is not so in airships intended for commercial purposes, where more weight can be allotted to the hull structure. It is also stated that in the projected Empire airships, not only will the hull be of much stronger construction than in L. 72 class, but the length will be relatively less and the diameter relatively greater, experiments carried out since the War having shown this modification to be of advantage. It is to be hoped that such will prove to be the case, but until full-scale experience has confirmed the labratory results, there will be room for doubt.

The laboratory can indicate many modifications which may prove advantageous, but it fails to produce all the conditions of actual flight. The experience of an airship caught in a violent storm, as was the Dixmude, cannot be reproduced in the wind tunnel of the Laboratory. In such circumstances the ordinary seaborne ship has a great advantage, for she can run before the storm if necessary, and still maintain a course, since she has a speed relative to the water and can use her rudder. She can seek out a sheltered harbour and moor without great difficulty. All she has to avoid is a lee shore.

An airship caught in a storm is in a far more desperate plight. The earth and the water below are for her the lee shore which must be avoided. She is floating in a medium of her own density and like a huge bubble of air caught in a mighty current, whose speed and direction are constantly varying, she is forced hither and thither, and the greatest care and vigilance are required from her commanding officer to avert disaster. If she runs before the wind, as the ordinary ship does in similar case, she may at times, due to the currents meeting her moving more rapidly than herself, be reversed in direction, exposing her broadside to the fury of the gale during the operation. The next instant her bow or stem may be pressed down by nearly vertical currents of air, necessitating the use of her elevators to bring her to the horizontal position. In such circumstances the navigating is far more difficult than in an ordinary ship, since the latter has only her rudder to attend to. The navigating abilities of the officers of an airship will be tested to the utmost and if they prove inadequate, disaster must result. It is quite probable that in such circumstances the Dixmude met her fate. She had not sufficient speed or petrol to progress against the gale, the only condition in which some sort of control over her course and height could be maintained, and perforce had to fly before the wind. Blown in all directions she finally crumpled, fire broke out and she fell into the sea. As before remarked, the laboratory cannot reproduce such desperately trying conditions.

The problem is a difficult one, where the skill and endurance of man are pitted against the mighty forces of nature, without the least chance of obtaining a respite or shelter. In the end it is probable man will triumph as he has done in other almost insoluble difficulties, but the nature of the problem is different from others which have previously been presented.

One practical conclusion can, we think, be drawn from the experience of the Dixmude, and that is that in those regions in which storms arise almost without warning, numbers of airship sheds or mooring masts must be provided to which the airship can fly in times of peril. But even in such refuges numbers of men are required to safely dock the vessel or bring her to her moorings. The operations involved are far more difficult than the mooring of an ordinary ship, and in the future will have to be simplified. All who are interested in the develop-

ment of the rigid airship must now turn their attention to the recently-completed American naval airship—the Shenendoah — which has successfully carried out trial flights. In this ship one danger has been obviated by the use of helium in place of hydrogen for filling the gasbags. Already there has been a proposal to let her fly to the North Pole, a project which, according to report, her commanding officer has stated to be dangerous. It is possible that with the fate of the Dixmude before them, the United States Naval Authorities will cancel the projected voyage, if they had seriously entertained it.

THE PHYSICAL AND OPTICAL SOCIETIES' EXHIBITION.

(*Concluded from page* 21.)

IN continuing our comments on last week's exhibition of physical apparatus, held at the Imperial College of Science and Technology, we may first mention a few further novelties of the Cambridge and Paul Instrument Company. These are the outfit for automatic temperature control which embodies the ball relay of Dr. Guy Barr (illustrated in Fig. 24 of our article on the Galitzin seismograph, ENGINEERING, April 13, 1923, page 476); the new Duddell-Mather wattmeter, now made for pressures up to 75,000 volts, in which the live parts are kept 12 in. apart so that the glass case of the instrument attains dimensions of 50 in. by 38 in. by 33 in.; and the F. E. Smith difference bridge, as perfected by Mr. Smith and the firm, for highest accuracy work. The lead resistances in this bridge need not be equal, but are eliminated by taking two observations with connections reversed by the aid of a six-pole reversing switch; the bridge is used for the cable research and insulation tests of the Institution of Electrical Engineers. The universal testing set, a portable box for outside work and laboratory, should be also noticed on account of its ranges, 0·0001 volt to 600 volts, 10 microhms to 10 ohms, etc.

The new patterns of the Collins stress recorder, of the firm, illustrated in our issue of January 19, 1923, are fitted with a time scale in tenths of a second and a graticule to read in tons per square inch., 0·01 mm. being equivalent to 0·03 ton per square inch; free vibrations of 1,400 per second have been recorded clearly. The vibrograph of Mr. W. G. Collins is a seismometer, the elastically-suspended weight of which tilts the recording pen, which draws its curve on the outside of a cylindrical celluloid film; the time record is simultaneously marked, generally in tenths of a second, on the inside of the film, through the hollow axis of the cylinder drum. The driving clock can be set to different speeds by means of a lever, so that the changes in the rate of vibration of a bridge are recorded while first the heavy engine and then the lighter cars of a train are passing over the structure.

The metrocline, exhibited by Messrs. C. F. Casella and Company, is an exceedingly simple instrument for accurately indicating the deflections under load of bridges, beams, etc. The instrument consists of a base, a deflection rod sliding through the vertical arm of the base, pins fixed to the rod and a dial. We shall give a detailed description of this instrument later.

The chief novelty of Messrs. Bellingham and Stanley, of Hornsey Rise, was a photometer attachment to the spectrophotometer, described on page 659 of our issue of May 26, 1922. With the aid of this valuable attachment, the light absorbed by any solution can be determined both in the visible and in the ultraviolet spectrum, as well as the amount of light reflected from any surface.

The Davon super-microscope for metallography of Messrs. F. Davison and Company, is made in two forms, in the laboratory style for research and magnifications up to 5,000 and more, and in the metal works style for quick operation and magnifications of 100, 250 and 500; the latter arrangement is due to Dr. F. Rogers, of Sheffield. The special feature of the microscope is that the usual eye-piece has been replaced by a microscope (called the secondary) by interposing a specially-designed lens (called the collector). Photography is performed with the aid of three lenses (or lens combinations), the primary objective, the collectors and the secondary objective; for visual examination a further eye-piece is added. In the research super-microscope the parts are horizontally mounted on a solid cast iron base; in the works style, the microscope is vertically mounted in the upper portion of a vertical box camera, several feet in height, near the bottom of which a silvered card focussing screen is kept in exact register by springs. The specimen is placed on the top of the box (opposite the lantern which stands on a raised table), above the primary objective and the worked cover-glass vertical illuminator.

One of the monocular microscopes of Messrs. Ogilvy and Co., of Bloomsbury-square, was so arranged that a binocular attachment could at once be fitted to it, without requiring any further adjustment; they also exhibited a new photographic distance meter. We may mention the surveyor's levels and the theodolites of Messrs. Ottway, of Ealing, who also showed a steel mirror which was still untarnished after three months' exposure to the atmosphere, and the various optical and electrical instruments of Messrs. W. G. Pye, of Cambridge. The latter comprised a Bragg X-ray spectrometer with ionisation chamber and a three-valve radio set for wave-frequencies from 100 up to 4000, the parts of which required no plug connection and were all mounted on one base which could be turned about its horizontal axis.

The chief exhibits of Messrs. Newton and Co. were their episcopes and demonstrator's science lanterns. In the construction of their Ross kinematograph projector, which is fitted with a Ross high-intensity searchlight lamp, Messrs. Ross, Limited, have paid particular attention to even distribution of the light over the gate aperture and to diminution of the heat effects of the arc. When an arc reflecting mirror is used as in searchlights, the heat concentrated on the gate aperture endangers the safety of the celluloid film. The lamp casing is hence made double-walled of corrugated sheet metal and is provided with radiating fins, and the light issues through a negative lense; with a current consumption of about 6 amperes a uniform illumination of the screen is obtained.

The compact simple X-ray spectrometer of Messrs. Schall and Son, of New Cavendish-street, was mentioned by Sir Oliver Lodge in his recent discourse on X-rays and atoms.* The firm also exhibited the radium balance of Dr. Russ and Mr. Clark, of the Middlesex Hospital, for the control of radium tubes, and their double induction coil-plant for deep therapy by currents at 230,000 volts. The two coils, electrically in series and insulated by a bakelite and paper composition and by ¾ in. of wax (on the outside) are installed in a cabinet which supports the large-sphere spark-gap; the circuit further comprises another spark gap and two water resistances to prevent high tension surgings and inverse electromotive forces. The X-ray bulb is a large gas tube provided with an automatic relay for admitting a little gas when the rays become too hard. This is done by turning a small gas flame on to a small palladium tube at the side of the bulb; the hot palladium is permeable to the hydrogen in the gas flame which can thus pass into the bulb. Boiling water is circulated through the anticathode to maintain its temperature and thus keep the secondary current constant within 0·2 milliampere.

Messrs. W. Watson and Sons had their optical and electro-medical exhibits on different stands. The former comprised a universal binocular microscope-body adaptable to all objectives; new series of Chance-Watson colour filters for photomicrography and visual work, made in ten shades, of wave-lengths 4,300 to 7,000, of pot glass; and the Nelson cassegrain dark ground illuminator for oil immersion objectives. Of their other exhibits the new large-size Potter-Bucky diaphragm (Victor type) for deep therapy would be of greater interest to the engineer, if it could be utilised for metallographic research. The design incorporates the work of Bucky and Potter. In order to secure better definitions of X-radiograms and to suppress stray radiations, H. Bucky passed the conical pencil of X-rays through a kind of honeycomb grid; to minimise the shadow effect of this grid, H. F. Potter, of Chicago, imparted a slow uniform motion to the grid. A 200,000-volt deep therapy X-ray bulb, of the Coolidge tube, was also exhibited; it was made of soda glass and provided with a tungsten anticathode, the stem of which was fused to a rod of molybdenum, again fused to a steel rod.

The Otis King patent calculator of the Carbic Company, of Holborn Viaduct, consists of two tubes, turning and sliding within one another, and each provided with a spiral scale, and a third shorter tube, the cursor; the latter carries an upper and a lower mark. The cursor is made of opaque metal, and the marks are on the outside of the bevelled edges. If the cursor material were transparent, the marks might be made on the inner face of the cursor, which might be more convenient, perhaps, for setting.

In the new mining level of Messrs. Cooke, Troughton and Simms, which rests with a ball-levelling head in a duralumin tripod, the vertical vernier circle and sighting tube are attached to an arm which can be turned about a horizontal pivot of the inside compass-box frame, which is provided with a screw-down bezel ring. By swinging the arm, the telescope can be inclined at any angle, whilst with the usual arrangement measurements are limited to angles of about 50 degrees. The tube carrying the same lenses at both ends, the observer may apply his eye to either end; the illuminating diaphragm is midway between the two lenses. The firm has also taken up the manufacture of the "cosmos radiobrix," small cubical boxes of about 5 in. which fit neatly together to form a complete radiophone set.

The new vertical projection machine, demonstrated by Messrs. Alfred Herbert, of Coventry, consists of a measuring bench and a shadow table in front of it, both these parts resting on the top of the cabinet for the pointolite lamp, and a standard carrying at its upper end, 10 ft. above the floor, a horizontal plane mirror which throws an image of the specimen, magnified up to 50 times, on the shadow table. The respective template is also placed on this table; by adjusting two slides, the image and template are made to fit into one another, so that measurements of discrepancies can be taken. The bottom slide moves backward and forward, the top slide, running on balls, moves sideways. The specimen may be held by centres or by a vice. The 100 c.p. lamp is fitted with a 3-in. focus Dallmeyer projection lens. The floor space occupied is 28 in. by 33 in., the weight, 770 lb.

The only novelty, not so far noticed in our columns, shown by Messrs. George Kent, Limited, was the temperature controller for steam-heated dye vats and similar purposes; we shall deal with this instrument later.

In the new dead-beat compass of Messrs. Henry Hughes and Son, strong damping is obtained by means of eight radial wires, which are attached to the copper cap of the card (resting on an iridium point) and are bent up and down at their outer ends without being joined to the card; the motion of the wires through the liquid (alcohol) sets up eddy currents. The strong magnets system consists of two needles, 2½ in. long for a 6½ in. cord. The ship's depthometer of the firm is to indicate the height of the oil in a tank. It is simply a hand-compression pump, about a foot high, the barrel of which is connected on the one side, by a rubber tube, to a copper pipe inserted in the oil, and on the other side to a mercury gauge; when the pump piston is depressed, the mercury is raised to a height corresponding to the depth of the immersion of the pipe in the oil.

The Eötvös gravity balance, exhibited by Messrs. L. Oertling, has been constructed after the original instrument, which the late Professor Eötvös despatched from Budapest over to this country just before the war, and which arrived safely after it. These balances having proved of practical utility in Hungary, in spite of their extreme sensitiveness, are now being used in this country and the Dominions in searches for ores and oil. Among their other balances was one designed for Messrs. Willis, especially for ascertaining the moisture in tobacco. In his responding adjustable balances for accurate weighing, tested at Teddington, Mr. R. W. McLachlan,

* ENGINEERING, November 9, 1923, page 598.

of Enfield, applies a correction to the two outer of the three knives of equal arm balances, by means of screws, made of delta metal, which have twelve threads to 1½ thousandths of an inch; his electric damping device, a small electro-magnet tapping at the end of the pointer, is used for the calibration.

The strainmeter of the Foster Instrument Company, of Letchworth, was illustrated on page 772 of our issue of December 21 last. In the record mechanism of their automatic temperature control for gas furnaces, the leads from the thermograph inserted into the furnace are joined to two contacts of the pressure bar and to one contact on the pen of the recorder and are thus connected with an electric relay which operates a valve in the gas pipe. Smaller thermostatic devices for gas-heated furnaces were exhibited by the Sigma Instrument Company, also of Letchworth; in this case the thermostat consist of a bent bimetallic strip. In the very delicate Gowy regulator for gas flames a toluene thermostat actuates a contact pin dipping into the mercury meniscus of a glass tube, and this pin is constantly oscillated up and down by a small electric motor.

In the Freas electric ovens of Messrs. J. J. Griffin and Sons, of Kingsway, temperature control within 2 deg. (for ranges up to 180 deg. C.) is obtained by the expansion of three vertical rods, two made of a copper alloy and one of copper. When the temperature rises too high the upper of two electric contacts is raised; these are short cylinders mounted in a glass tube in front of the oven casing. The micro-furnace of the firm, for the rapid analysis of metals, ores and salts, by sublimation, is due to Mr. Fletcher, of the University of Dublin. The furnace consists of a cylindrical cup in which a thin rod of carbon, about 1½ in. long, is heated by an adjustable current; the specimen is put on a glass disc which is placed over the rod; the vapours liberated condense on the colder portions of the glass. Various laboratory apparatus, including electrometric titration apparatus, were also exhibited by Messrs. A. Gallenkamp and Co.

Of the varied exhibits of Messrs. Negretti and Zambra, we may mention the hydrograph for cold stores, &c., the hairs of which operate directly on a crank pin on the magnifying pin-arm spindle, a recording Assmann psychrometer, and the new surveying barograph, the interesting details of which require special description.

Mr. J. Rheinberg's exhibit of framed colour designs on paper and textiles deserve attention. The original material looks a uniform grey or dull colour tint; by a single printing operation in black varied colour patterns, comprising spectra and peacock-eyes, are produced. The material contains the colours to be brought out, on the paper in parallel ruled lines, in textiles in the interwoven threads; the black printed on in dots or lines, &c., obliterates the colour in certain parts allowing it to stand out in others. Thus the expensive colour-printing processes may be improved. Very exact registration will not be required in most cases; a child's face with a red eye and a blue cheek would be fatal, but in pattern colour printing such accidents would not occur.

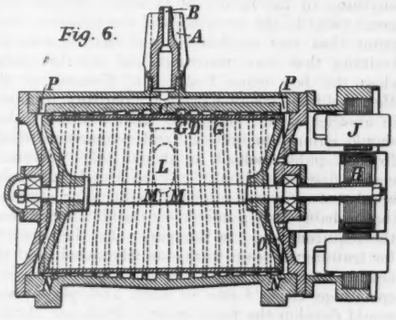
The Darimont cell of the Darimont Electric Batteries, Limited, Salisbury-house, E.C., is a two-fluid zinc-carbon cell. The S-shaped zinc plate stands in a porous cell containing a solution of common salt, the carbon is outside in ferric chloride. Both these solutions further contain some secret constituents and are styled hemiporigene and radiogene respectively. Tests conducted by the National Physical Laboratories show great constancy of the electromotive force (1·6 volt) on open and closed circuit.

Among the novel specialities of the Dubilier Condenser Company, of Goldhawk-road, W., for radio circuits were the simple minicap switches for working amplifying valves and other operations, and the anode resistances (up to 100,000 ohms) and grid leaks (up to 5 megohms, made of impregnated fibre), for wireless receivers. The chief insulating material of the firm is ruby mica, of which many thin foils are superposed. Several of the exhibits of the Igranic Electric Company: the honeycomb tuning coils, the "gimbolder" coil holders and the "vernob" vernier adjustment knob (a rod to be turned by hand, the rubber end of which rubs against the bevelled edge of the ebonite vernier of a condenser) were also intended for radio service.

The Marconi high-speed electric drum recorder for the reception of as many as 650 telegraph signals per minute, which was exhibited by Marconi's Wireless Telegraph Company, was described in the Physical Society last August by Dr. N. W. McLachlan; the instrument is not affected by shocks and the rolling of a ship. The firm also showed the Marconi otophone, a portable instrument weighing 14 lb. and embodying two valves, by means of which the deaf can hear, *e.g.*, follow a general conversation, when applying a headpiece to the ear or also to the forehead.

The "dull-emitter" valves, exhibited together with other apparatus for radio-telegraphy and telephony by the M. O. Valve Company, and by the Mullard Radio Valve Company, have much been discussed of late. The filaments of the valves are heated by battery currents to emit electrons; the efficiency of such emission is normally very low; but in the dull emitter the filament need not be raised to incandescence, and weak heating currents suffice. In an M.O. valve, two dry cells, giving only 60 milliamperes to the filament, are said to allow a plate current of 10 milliamperes, to flow by the stream of electrons. There is thus a considerable saving in filament current supplied by the battery with a correspondingly increased efficiency in reception. In the Mullard "Wecovalve," which consumes 0·25 ampere at 1 volt, the efficiency is stated to have been improved by coating the finished filament with thoria or some other materials of high electronic emission; a certain percentage of thoria is generally mixed with the tungsten oxide in preparing the filaments. Such a filament would be a kind of Wehnelt cathode. The new D.F.O.R.A. valves of the Mullard Company require only 0·06 ampere at 2·5 volts for the filament. How these superior efficiencies are obtained in that case and in the M.O. valves is not disclosed; it might be by special treatment of the filaments after mounting in the valve or by adding compounds of rare metals to the filaments.

Fig. 6.



The Mullard Company also made an impressive display of silica valves for high powers, from 1 kw. up to 4 kw.; the largest sizes listed are 25 in. long and 4½ in. diameter. The most noteworthy exhibit of theirs was the Holweck molecular pump, a modification of the Gaede pump due to F. Holweck, of Paris, in which the gas molecules in kinetic motion are made to rebound from a surface, itself moving at high speed. This moving surface is the aluminium cylinder D in the diagram, Fig. 6, which revolves at 4,500 r.p.m. within the fixed cylinder inside of which are cut the shallow spirals M, M, left- and right-handed respectively in the two halves of the cylinder. The air in the central space between the two spirals is driven from the centre to either end of the cylinder, where it enters, at P, the space connected with the rough pump, whilst the central space is connected to the vessel to be evacuated through the tubes L and A, the latter being the wider of the two tubes seen at the top of the diagram; the smaller tube B is joined to the rough pump; the two tubes A and B appear to be concentric, but are behind one another. The cylinder D rotates in ball bearings and is driven by an induction motor H, the rotor of which is enclosed in a space connected with the rough pump, whilst the stator J is outside the casing. A small rotary convertor supplying the stator with two-phase currents takes its supply from 110 volts D.C. mains. The energy consumption is only 10 watts. Friction has been so effectually reduced that a good vacuum having been obtained, the drum will continue to spin under its own momentum for ¾ hour. When the rough pump, has reduced the air pressure to 1 mm. of mercury a vacuum of 0·00001 mm. can quickly be produced; even lower pressures can be maintained, and the pump has been kept working every day for nine months without interruption.

It is perhaps characteristic of the great popularity of the Pointolite lamps that the Ediswan Electric Company limited their exhibits practically to the same great variety of these lamps as last year. Several of the other large electrical firms made good displays of the varied ranges of their productions. Messrs. Elliott Brothers, Limited, drew attention to their multiversal test set and their multiversal transformer. The latter instrument has five self-contained primary ranges of 100, 50, 20, 10, 5 amperes; by winding cable through a horizontal hole, which passes right through the box of about 1½ ft. cube, additional ranges, rising in 10 steps from 150 amperes up to 1,500 amperes, can be obtained. The transformer contains a liberal iron section; owing to the large number of primary ampere turns, the ratio-curve is practically a straight line, and the phase-angle between primary and secondary is negligible. The hole mentioned being provided with a substantial tube of insulating material, bare conductors (up to 12 turns) may be placed in it.

The constant pressure "Meg" insulator tester of Messrs. Evershed and Vignoles, was described on page 11 of last week's issue. Among the other novelties exhibited, was the "Ducter" potential ohmmeter, which is of the megger type, but designed to measure resistances from a few ohms down to one microhm. The movement consists of two coils adapted to determine the ratio of the potential to the current flowing between two points of the conductor under test; the two battery terminals are at one end of the instrument, and the two pairs of potential and current terminals at the other end are connected with the resistance to be tested by hand plugs, the handles of which are provided with distinctive markings. The Evershed hand generators for high-tension radio transmission are also of the megger type. The four-ring commutator and brush gear of the small generators are connected up to reduce the voltage at the point of commutation; ripples and humming are suppressed. The armature of a larger motor-driven generator is wound with two coils to supply both low-tension and high-tension currents. In the construction of the automatic transmitter set for aeroplanes, of Captain Frost, R.A.F., the firm is associated with Messrs. Gambrell Brothers, of Southfield. On the cylindrical circumference of a cylindrical plug, fitting into the casing, contacts, for signals likely to be frequently used such as S O S are grouped; when the handle of the instrument is turned, this signal is automatically repeated. Of the other exhibits of Messrs. Gambrell Brothers, we may notice the high-resistances, made of carbon, the simple megohm box bears ten terminals for subdivisions of 0·1 megohm.

The rotary synchroscopes of Messrs. Nalder Brothers and Thompson, Limited, of Dalston, were described on page 22 of our issue of January 12, 1923. Their new overload relay, with definite time lag, the invention of Mr. C. L. Lipman, of the firm, is a relay for the protection of A.C. systems. The overload and time settings are adjusted independently, the standard being from 80 per cent. to 200 per cent. of normal load, and from 0·2 second to 5 seconds. When the current through the operating coil becomes equal to, or larger than, the load setting, the clock mechanism is automatically started up, and at the expiration of a period, determined by the setting, the relay operates the main switch. Both the load and time elements are of the self-restoring type, and the contacts can be arranged to close or to open the trip circuit. The clock, once wound up, will be able to operate 50 times on a 5-second lag, and more frequently with shorter lags.

The very compact temperature recorder of Messrs. Siemens Brothers and Company gives four records in different colours on the same card in a

metal case with sloping glass front, 10 in. by 15 in. by 13 in., weighing 50 lb., which encloses a millivoltmeter, a four-way automatic switch and a clock. The scale-length of the moving-type voltmeter is 4¾ in.; the armature of the automatic switch is energised every 37 seconds from a 4-volt accumulator through the clock, which also changes the position of the inking rollers. The indicating pointer is fitted with a blunt knife edge and swings beneath a chopper bar which presses the pointer against a roller and thus makes a dot. There are four rollers which automatically replace one another after each dot, the switch changing over to the next pyrometer at the same moment. The chart paper is marked with hour and minutes divisions along the lower edge; the paper is perforated along the edge, and a sprocket wheel driven by the clock feeds the chart paper forward at the rate of $\frac{1}{18}$ in. per hour; one roll of chart paper will last two months. Temperatures are read through the celluloid scale laid over the chart. The clock work consists of a master, wound up once a week, and a slave, controlled by an escapement on the master, to control the chopper bar. The instrument can be used with either distance thermometers or thermocouples. The lamp-signalling system of the firm should also be mentioned; their thermocouple potentiometer was illustrated on page 458 of our issue of April 13, 1923.

The K. C. Cox selenium magnifier for submarine telegraphy, which we described on page 37 of our issue of January 14, 1921, is now a commercial article of Messrs. H. W. Sullivan, of Winchester House, E.C.; for ordinary practice magnifications of from 200 to 1,000 are sufficient, but they can be pushed up to 10,000 and even 20,000. The selective hot-wire microphones of Major W. S. Tucker, R.E., also exhibited by the firm, were mentioned in our comments on the British Association discussion on physical apparatus for biological purposes (October 6, 1922, page 419); his non-respondent gun-microphone, exhibited by Messrs. Sullivan, detects impulsive sounds produced by guns, whilst the resonant microphones record musical sounds. In order to demonstrate the performances of their standard heterodyne wavemeters Messrs. Sullivan had coupled two frequencies of 101,000 and 100,000, and coupled the differential frequency of 1,000 again with one of 1,001 so that one beat was heard per second, magnified by two valves.

The co-ordinate alternating current potentiometer of Messrs. H. Tinsley and Co. is due to Mr. Douglas C. Gall, a partner in the firm. It consists of two potentiometers, the one giving the e.m.f. in phase, the other in quadrature, the comparisons being performed for magnitude and phase by dials. The absolute e.m.f. values are fixed by means of a reflecting dynamometer; phase angles are measured with great accuracy. Among other exhibits of the firm we notice the Campbell-Butterworth frequency bridges, and the apparatus for measuring the capacity and inductance of valve generating sets for frequency ranges from 200 up to 5,000; the decrease of the frequency produced by loading the generator is compensated for by adding inductance.

NOTES.

Inland Waterways.

THE paper read by Mr. E. Manning Lewis, on Monday last, on "Inland Waterways," before the Institute of Transport, put forward the plea that a trial should be made to resuscitate inland navigation in this country, commencing with the modernisation of the Bristol Channel to Birmingham route, and urged that this could easily be carried through if some one with great energy would throw himself into the scheme. Mr. Lewis's paper formed an interesting review of the present position of canals, and of their sufferings during the war and subsequently. The canals were not protected during the early part of the war, and suffered by loss of staff. At the same time they were not secured, as were the railways, against increasing working costs, so that, as Mr. Lewis put it, it was more as owners of valuable property in populous districts that they made any profit than as owners of waterways. Mr. Lewis's treatment of the question he set himself, as to whether the canals were worth preserving, does not seem to us very satisfactory. As a reply, he proceeded to state that there was no doubt that if an interest were taken in the matter, England could possess one of the finest waterways systems in the world. But a fine waterway does not necessarily imply traffic. We believe at the present time the New York State Bay Canal, modernised in recent years at heavy cost, is a pronounced failure, and that the increase of traffic which was expected to follow the reconstruction has not materialised, at any rate, not sufficiently to enable anyone to point to the undertaking as a success. Mr. Lewis pointed to the railway grouping as a danger on account of the elimination of competition, yet implied elsewhere that traffic, which, it is alleged, cannot be handled remuneratively by the railways, should be reserved for the canals. This surely would also eliminate competition, and should, therefore, not be encouraged.

Education and Industry.

At the recent annual conferences of the various educational associations many papers were read and discussions held on questions relating to the education of those who intend to take some part in industrial activity. Mr. Gerard Fiennes, speaking at the conference of the Association of Headmasters, advocated the type of education obtainable at an English public school for those who are to take part as leaders in industry. The qualities which the system gives have been shown to be of service in many fields, and the characteristics of those who have benefited by the training in discipline, capacity for team work and ability to control men without anything in the nature of tyranny, should be of great value in the workshops of the country. One point that was emphasised was that it was the training that was important and not the social class the boy came from. Mr. Fleming of the Metropolitan-Vickers Electrical Company, Limited, in another paper, suggested that whether a boy should enter into industry and commerce directly from a public school or should take university classes first, should only be decided with knowledge of what work it was intended to do. For engineering probably only a university training would meet the requirements. In this paper also the necessity for training in team work was advocated, and the headmasters of all schools, it was suggested, should encourage those forms of work and play which would develop the team spirit. Professor Arthur Smithells, in his presidential address to the Science Master's Association, contended that, although the introduction of science teaching into schools had proceeded actively and had greatly extended, the results had only shown a disappointingly small dissemination of scientific knowledge of an available kind among the people. School science should be a matter of general education, and not in any sense as preparing a few boys for subsequent professional study.

The Model Engineer Exhibition.

Nowadays there is such a marked tendency towards the introduction of repetitive methods of working in engineering, in order that production costs may be reduced while wages are maintained, that there is a grave danger that the available number of real craftsmen may be much reduced in the future. Other means than those used in the past to maintain the excellence of handicraft, may be found, and anything which may serve in this way is deserving of appreciation. The pursuit of model-making is one form of activity which will prove useful. If evidence were necessary that such is the case, a visit to the Model Engineer Exhibition at the Horticultural Hall, Westminster, would convince the most sceptical. In this exhibition, the seventh of its type organised by the proprietors of *The Model Engineer*, there are many and excellent examples of work, and the average standard of workmanship is decidedly better than in any former year. In the competition section there are more than 150 articles entered, and the variety of subjects dealt with is greater than ever. Where all is good, the judges must have great difficulty in making their decisions for the awards of the various cups and prizes. Of the many articles shown, some catch the eye not only because of their excellent craftsmanship, but also because of the novelty of the article as a subject for treatment. Among these there is a five cylinder radial aero engine with cylinders of 1¼-in. bore and 1½-in. stroke, which it is said has been run to give a maximum power of 4·6 brake horse-power at a speed of 5,800 r.p.m. It was made by Mr. G. Smith, of Caldecott, a young apprentice, with the use of a 4-in. Drummond treadle lathe. Another excellent feature of the show is the number of models loaned for exhibition. Perhaps the most exceptional example of model making is shown in this section. It is a model of a 15-in. howitzer, constructed to a scale of 1 in. to a foot by Admiral Sir Reginald H. S. Bacon, the President of the Society of Model and Experimental Engineers. Locomotives are numerous and of excellent workmanship, and the track erected in the hall is used for running demonstrations. Mr. Crebbin's model of a 4-6-2 locomotive with four cylinders, using superheated steam and working with compound expansion, affords an interesting example. Of trade model exhibits, there are many, and the small tool manufacturers have arranged a good representative show. Any visitor to the exhibition must be impressed with its popularity as well as the limitations of the hall, otherwise the most suitable one available. If the growth of interest continues larger premises will be necessary and the Exhibition must be open for a longer period.

The Crude Oils of Sarawak and Persia.

Since 1911, the oil production of Sarawak, Borneo, has steadily risen, particularly since 1920, to 403,394 tons in 1922, and with the present weekly output of 11,000 tons, Sarawak ranks second among the oil-producing countries of the British Empire. The oil from different areas, Mr. J. Kewley, M.A., pointed out in a paper read before the Institution of Petroleum Technologists, last Tuesday, is fairly uniform in character, and has an average density of 0·902; it becomes lighter as found at greater depth—a common observation, partly ascribed to the loss of gas in the upper strata. The crude oil is a mobile liquid, reddish-brown in colour, of agreeable odour, high refractive index, very low-coking value, low sulphur percentage (0·35), high initial boiling point (97 deg. C.), high carbon-hydrogen ratio (7·2), and low viscosity, and is easily refined; there is a refinery on the Trumble system at Lutong. The oil is naphthenic, free from asphaltenes and paraffin wax. As regards the products, the gasoline from the Miri crude (14 per cent. of the crude) has a very high density, 0·786, bears high compression (5·3 : 1) and is blended with Sumatra gasoline richer in gas; it requires no refining and does not corrode copper. The kerosenes are not good lamp oils, but the residual oils make a good fuel for furnaces and Diesel engines. The heavy lubricating oils have agreeable odour and colour. The "Crude Oil of Maidan-i-Naftun," which Dr. A. E. Dunstan has submitted to extensive researches, described by him the same evening, is of a very different type; it resembles Mexican oils, as Mr. McConnell Sanders remarked during the discussion. The oil production of the Anglo-Persian Oil Company has likewise grown steadily since 1912, especially after the war, and amounted to 2,913,908 tons in 1922–23. The Maidan area is 140 north-east of Mohammerah on the Shat-el-Arab; the big refinery lies on Abadan Island, not far from that port. The oil is found in a dolomitic limestone, to which it has travelled a long way, as Mr. Cunningham-Craig suggested. The oil is rich in gas; the pressure in the mains is 55·6 lb. per square inch, and the gas, largely methane and free of helium, contains 10 per cent. of sulphuretted hydrogen, a quite unusual and troublesome amount. The mobile brown crude oil leaves the well free of water; it is an oleosol of very little asphalt and wax dispersed in hydrocarbons. At 120 deg. C. the oil partly decomposes, liberating water and colloidal sulphur. The once-run distillate (20 per cent. of the crude) gives a gasoline (with 10 per cent. of aromatics), which can be refined by means of hypochlorite instead of sulphuric acid. The kerosene has to be filtered through bauxite to remove the sulphur. The residual oil can be cracked at 300 or 400 deg. C; the yield of heavy lubricants is small. The ashes, which are faintly radioactive, contain vanadium, nickel and manganese; in what way these metals may have acted catalytically in the formation of the

oil, is obscure. Dr. Dunstan's chemical investigations are very valuable, and both the papers are theoretically and practically important like all studies of crude oils, which have been taken up almost too late.

THE CONSISTENCY OF RUBBER.

The paper on the "Consistency of Rubber and Rubber Compounds," which Dr. S. S. Pickles read before the Institution of the Rubber Industry last Monday, dealt with problems which have long troubled the manufacturer, but have only in quite recent years received adequate consideration. Dr. Pickles' views are in consequence well worth summarising. Rubber, he said, is credited with nerve, grain, and a tendency to knotting; it is said to have flip or to be dead and leathery and to have other undesirable or desirable properties. That rubber turns hard and opaque in the cold has long been known, and the unpacking of the bales is still a matter of annoyance, because once hard, the rubber tends to revert to that condition. The hardness is cured by heating or by bending. When hard rubber is pulled, it hardly yields at first, but then stretches suddenly; the hysteresis loop is almost rectangular, but in repeating the experiment with the same specimen, the loop narrows more and more. When pure rubber is heated, its specific gravity is diminished. By systematic heating and cooling Bunschoten and Van Rossem found, that heating up to 20 deg. C. and 25 deg. C. had hardly any effect, but near 30 deg. a sudden drop in density from 0·93 to 0·917 occurred, while further heating to 100 deg. again had little effect; on cooling again the old density was nearly regained on a straight line curve, but the last recovery took months in cold stores. As regards accelerators, Wiegand and others distinguished inactive fillers from active reinforcing ingredients which stiffen the rubber. In order to counteract the varied influences of the many modern additions to rubber softeners, carbon black and mineral and vegetable compounds are used; of these naphthalene, an expensive and dangerous material, has the same disintegrating effect in 1 hour that vaseline has in 4 hours, and castor oil in 40 hours. The "grain" is something akin to the fibre structure of wood; it is owing to grain that rubber stretches at different rates in different directions. The rubber itself, its treatment and its admixtures, contribute to the grain effect. Calendering causes sheet rubber to split parallel to an edge; extruded and moulded rubber or rubber made by crossing the plies will split spirally when strained; a solid tyre may burst near the band, or stone grit may make it peel in concentric caps. Calendering, magnesium carbonate, tripoli powder and other crystalline fillers have strong grain effects, much stronger than zinc oxide and carbon black, but much depends upon the thermal and mechanical treatment of the rubber. The "tearability" of rubber has been investigated by E. C. Zimmermann by tests similar to the tensile tests of 8-shaped cement slabs; the other test in which the square specimen is partly slitted across seems less reliable. "Knotting rubber" appears to develop local centres of strong resistance to tearing; the property is welcomed in thread and tube rubber, but is little understood.

THE SHIPBUILDING INDUSTRY.

WHILE anything in the nature of a boom in the British shipbuilding industry cannot be regarded as in any way imminent, there do appear now to be reasonable grounds for hoping that the acutest stage of depression has been passed. The returns for the December quarter just issued by Lloyds' Register, when compared with those for the previous quarter, show distinct improvements in many important features. The work in hand has increased by 124,000 tons, or nearly 10 per cent. since the end of September, and the suspended work has been reduced from 242,000 tons to 164,000 tons in the same period. A year ago, we may remark, this incubus amounted to 348,000 tons. The tonnage commenced during the December quarter, viz., 244,056 tons, was more than double that started in the September quarter, and also shows some slight improvement in comparison with the June quarter, although it falls far short of the figure for the first quarter of the same year, which was 355,203 tons. The situation with regard to tonnage launched is somewhat similar. The December quarter figure of 114,583 tons is an improvement on that for the September quarter, which was only 66,474 tons, but is less than half the average for the three previous quarters. It will thus be obvious that in order to benefit the shipbuilding industry to any material extent the recent improvement must be continued and extended, and optimism is encouraged by the fact that the boiler-makers' dispute has now been settled and that trade prospects appear to be generally rather brighter. The total amount of work in British and Irish yards at the end of the year was 1,395,181 tons, which is still 5 per cent. lower than the corresponding figure for this time last year. The current tonnage includes 360 vessels, of which 291, making 1,065,770 tons, are steamers, and 55, making 323,641, tons, are motor-ships. Only 14 sailing vessels with an aggregate tonnage of 5,770, are included in the total, but the proportion of motor tonnage has steadily increased during the year from 8½ per cent. on December 31, 1922, to over 23 per cent. at the present time. The total merchant tonnage building abroad, on the other hand, is rather less than was the case at the end of September, the current figure being 1,049,155 tons comprised in 399 vessels, and the reduction amounting to about 5 per cent. The new tonnage laid down in foreign countries, however, has increased from 100,372 tons in the September quarter to 228,072 in the December quarter and this, together with the fact that there has been a steady reduction in the proportion of suspended work, may be taken as an indication of a prospective improvement in the foreign shipbuilding industry. The suspended work in foreign yards now amounts to only 67,000 tons, as compared with 216,000 tons a year ago. Nearly one-third of the total foreign tonnage under construction is being built in German yards, the figure for that country being 324,184 tons. Important contributions of over 110,000 tons each, are also made by Italy, Holland and France, but the United States have now only about 91,500 tons in hand. Four years ago, it is interesting to recall, the last-mentioned country had some 4,000,000 tons of merchant shipping under construction. The heavy production at that period, in fact, has had a powerful influence on the subsequent position of the shipbuilding industry of the world, and its effect is still likely to be felt for some time to come.

THE M.S. "CONDE DE CHERRUCA."—We have had forwarded to us the log of the m.s. Conde de Cherruca for a period of 20 months, and the general results are worth quotation. The Conde de Cherruca is a 6,500-ton oil tanker, built by Sir W. G. Armstrong, Whitworth and Co., Limited, of Newcastle-on-Tyne, for the Cia. General de Tabacos de Filipinas, Barcelona and Manila. She is 370 ft. long, 48½ ft. beam, with a moulded depth of 30 ft. There are two sets of engines, of the Armstrong-Sulzer-Diesel two-stroke type, of 2,500 b.h.p. at 100 r.p.m. The total distance run during the period covered by the log was 102,988 miles; the average fuel consumption per day was 8·5 tons for an average speed of 10·3 knots. The average daily consumption of lubricating oil for the cylinders was 12·5 gallons, and for other purposes 10 gallons, giving a total for all purposes of 22·5 gallons. A feature of the log generally is the short time which was required in port.

CONNECTING ROD ACCIDENT ON THE LONDON AND NORTH EASTERN RAILWAY.—Major G. L. Hall's report into an accident which occurred on October 8 to a locomotive on the Tebay Branch of the London and North Eastern Railway, traces the cause of the failure to a badly fitting crosshead cotter. The engine was still a good one for light work, having been built in 1880; it was of the 2-4-0 type. At the time of the accident one of the connecting rods fractured and the fire-box was penetrated with resulting injuries to the driver and fireman. If we follow Major Hall's description correctly the cause was due to the crosshead being loose on the piston rod. The cotter appears to have been old and driven much further down than it should have been, though quite possibly we think not so far as the "reconstructed" conditions indicated. There is no doubt from the description that this cotter had been loose, a state of affairs which every good fitter knows it is most important to prevent, for it leads inevitably to working, binding and fracture, if allowed to continue. In this case fracture did follow, and the failure of the connecting rod occurred as a secondary result of the neglect. The extreme importance of fitting such cotters accurately is fully realised as a rule, and this accident will probably serve to impress it afresh on the minds of any men who have got into the way of considering these things in too complacent a manner. The number of these in any case we believe to be few.

LITERATURE.

Modern Electro-Plating. A Guide Book for Platers, Works Chemists and Engineers. By W. E. HUGHES, B.A. (Camb.), D.I.C. (Lond.). London: H. Frowde and Hodder and Stoughton. [16s. net.]

IN ordinary language, electro-plating has acquired a very definite meaning, and by electroplated goods is understood those articles on which a coating of silver has been deposited by a particular method. It is therefore a little unfortunate that Mr. Hughes has chosen this word to describe his book, when many other terms would have declared his object without ambiguity. If anyone should procure this book under the impression that he will be able to examine the technical details of silver plating he will be disappointed, for at a very early stage the author announces, that silver lies outside his programme, since the metal is not one of prime importance in engineering. The author's interest is centred entirely in what is novel, and he does not hide his contempt for processes that have served their purpose so well that for half a century little improvement has been suggested. The solution of the double cyanide of silver and potassium is not without its drawbacks, the slow rate of deposition is perhaps regrettable, and the old-fashioned methods of working, are no doubt irritating to those who have busied themselves in modern processes, and to whom the quickly-obtained result is a merit. There is, however, a good deal of capital still invested in the antiquated silver plating industry—Sheffield and Birmingham are largely interested in silver plating—and the author admits that the results have obtained an acknowledged position in the world's estimation. Where no suggestion of improvement is made, little purpose is served by sneering at good work, in which traditional methods have supplied the place of scientific training, and experience has overcome technical difficulties by skill and patience.

In an introductory chapter, Dr. Hughes distinguishes carefully between electro-refining and electroplating, indicating the lines by which his treatise is limited. He recalls the scheme that was mooted a short time back to establish copper refining in the neighbourhood of Newton Abbott. In these times the introduction of a new, or the renovation of an old, industry, that promises employment to large numbers is an attractive proposition, while the proposal to utilise the beds of lignite for the generation of electricity, necessary in copper refining, makes the plan doubly inviting. Apparently the scheme perished stillborn, and has not been resuscitated, notwithstanding the inducements offered. Possibly the tactics followed in America for securing an ample supply of smelting material proved too powerful an opposition, but under any conditions it would be difficult, if not impossible, to obtain a sufficient supply of blister copper from home resources. Capital, and much would be needed for successful working, regarded the proposal as too hazardous, and it must be admitted that the attempted electrolytic extraction of zinc in this country conveys a salutary lesson. The process has been applied, and plant with a capacity of about 2 tons a day has been erected, but such small-scale efforts usually fail. An output of some 100 tons a day would be necessary to place the scheme on a satisfactory commercial footing.

Electroplating, the process by which metal is transferred from anode to cathode by the agency of the electric current is regarded as offering the prospect of greater commercial success. In this class of operations comparatively small plant can be utilised with advantage. There is no evidence of an industry growing up sufficiently large to react on engineering to any great extent, though during the war some new applications were tried successfully. Dr. Hughes regards nickel plating as progressing satisfactorily, and this development he attributes to the adoption of improved methods and technique. But the demand while confined to ornament and decoration is likely to remain small. The field of usefulness is limited to the coating of such articles as cycle and motor parts, sanitary fittings, saddlery, toys, &c., and is therefore of no prime importance in engineering, though it is said that 500 tons of metallic nickel are consumed annually in England for plating purposes. Cobalt

is looked upon with favour and is in some respects to be preferred to nickel. It is practically untried in this country, though the Canadians, the great producers of the mineral, speak well of it for plating purposes on account of its hardness and durability.

The deposits of these metals are prized on account of decoration, but zinc in the form of an electric deposit is highly valued by reason of its protective properties, and was largely used in the war for protecting sea planes and mines from the corrosive action of sea water. The process, as distinct from that of pot galvanising, is more used in America than with us, and the author suggests that the unwise enthusiasm of its advocates interferes with its commercial development. This method of protection cannot be applied in every case, and it is stated that articles subject to tension, as steel springs, and cycle spokes are likely to be injured if submitted to the process. The cause is not known with certainty, and the deteriorating effect has not been definitely measured. The author places the phenomenon among those obscure problems connected with the corrosion of iron and steel that are awaiting further examination. Electrolytic copper has received much attention, and is the one type of electro-deposition that has been seriously studied, for when pure copper is required the process has no equal. The method is so simple and certain in operation that little alteration has been made in recent years in commercial methods, and the scope for improvement is limited. The most unsatisfactory part of the general process arises in those operations in which it is necessary to use a hot cyanide bath to deposit a thin coating of copper on iron and other metals, to prevent the acid of the copper bath attacking the metal. The hot fumes from such baths must affect the health of the workers injuriously.

Iron plating is a comparatively novel process, and is still on its trial. Its use acquired prominence in the war time for restoring the worn parts of aeroplanes and armament to precise gauge measurement. The sudden demand demonstrated our state of unpreparedness and want of expertness in producing thick deposits of iron by continuous deposition. The method pursued was to deposit on the worn shafting, alternately thin layers of iron and copper, each not more than two or three thousandths of an inch thick. Later, a process of continuous deposition was worked out and thick deposits were obtained in one operation. Tin and lead are occasionally used in electro-plating, but are of so little consequence that the author might have passed these over on the same grounds that have led to the omission of silver.

With the view of promoting efficiency and economical working, a chapter is devoted to the theory of plating, intended to assist those who are in charge of electro-depositing processes. It may prove useful, but we cannot say that we think fragmentary extracts from the writings of Arrhenius, Hinrichs, and other authorities will prove very illuminating or beneficial. The Ionic theory or modern views on the theory of electrolysis will prove but an indifferent guide when practical difficulties arise, and possibly might be misleading. The insistance on the use of the microscope is a decided step in advance, and the micro-photographs, well reproduced, are very instructive. At the end of the book the author returns to the subject when considering the structure of electro-deposited metal and his remarks, both practical and informing, deserve the attention of all engaged in the industry. In this chapter, Dr. Hughes treats the deposition as a crystalline growth, and applies the known facts of crystallisation to explain the character and to control the modifications that are noticeable in the process of electrolysis. Admitting that the structure of a crystalline mass depends on the formation of nuclei, and the increase of the nucleus by continuous growth, he asks how the electro-deposited metal will be effected by the mechanical control of the factors which govern growth. The object is directed mainly to the production of a fine-grained deposit, since fineness of grain is accompanied by a high lustre, relative freedom from porosity, and comparative hardness. The aim of the plater is therefore directed to the formation of a fine grain, and it may be asserted almost as an axiom, that the greater number of nuclei formed in unit time and unit volume, the smaller will be the grain size of the crystalline mass. On the other hand, with a small number of nuclei the grain size will be large. The controlling factors or variables in the hands of the operator are current density, temperature, movement of electrolytes, or electrodes, and the chemical constitution of the solution. Each of these is considered in a highly practical fashion. Much of the authors' experience is incorporated in this chapter and is compared with the opinions and writings of other authorities. The arguments and illustrations are purely technical and cannot be summarised, more especially as some of the objects that it is desirable to secure are incompatible with others. For our own part, we are inclined to attribute the greatest effect to movement or agitation, if only one factor is varied at a time, but we are not prepared to say that the same effect could not be produced by combination of the other variables in suitable degree. The particular value of this chapter is its admirable summary of the existing literature with the references to original sources. As a practical guide it seems of greater importance than those other chapters of the book in which is described the preparation of the work, the constitution of the requisite baths, and the rules of practice to be followed in each of the several metals deposited.

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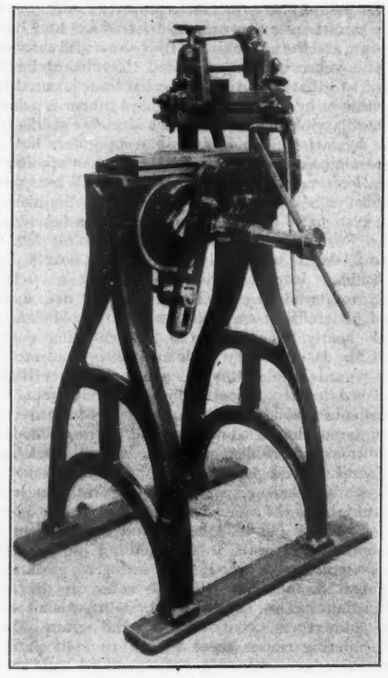
BOARD OF TRADE WAR MEMORIAL.—The memorial to the officials of the Board of Trade who fell in the war was unveiled by the Prince of Wales last week. It gives the names of 305 men who fell, out of over 2,000 who left the Board of Trade to serve with the forces.

SMALL PLANING MACHINE FOR HAND OR POWER OPERATION.

A SMALL planing machine designed and manufactured by Mr. Henry Milnes of the Ingleby Lathe Works, Bradford, which is shown at the Model Engineer Exhibition, is illustrated on this page. The capacity of the machine is such that it can deal with work 14 in. long, 8½ in. wide and 6 in. deep. It was designed to meet the requirements of model engineers and for small work in general engineering workshops. Provision is made for either hand or power driving, the pulley being situated on the opposite side of the machine from the hand-turned crank. The machine is actually a modification of what has been a standard production of this maker for many years, and the change consists in the use of the Whitworth quick return motion,



commonly fitted to shaping machines. The table is rack operated and returns at twice the cutting speed. Centred on the operating shaft, there is a sleeve, with three arms on it, which is used to convey motion from a cam on the large wheel of the Whitworth motion to a vertical rod to provide an adjustable and automatic cross feed for the tool. The first arm receives motion from the cam, while the second which is on the far side is provided with a slot in which connection is made for the end of the vertical rod. The third arm is at right angles to the second, and its end is spring-controlled and thus serves to bring the system back into the normal position after the motion has been transmitted. The top end of the vertical rod is connected to a bell crank lever on which a pawl is centred. This engages with the teeth of a wheel on the end of the horizontal screw for which the slide for the tool holder forms a nut. All the vertical motions are operated by hand adjustment.

THE ENGINEERING ASSOCIATION OF MALAYA.—We have received vol. II. of the transactions of this engineering association, which reproduces a series of papers read and discussed at Kuala Lumpur. They deal with "The Pipe Line and Workings at Gopeng Consolidated, Limited," "The Pengkalen Power Station and Electric Bucket Dredge"; with various roads: "The Johore Causeway" and "The Pulau Ubin Quarry."

THE ROYAL SANITARY INSTITUTE.—The Henry Saxon Snell Prize, in the gift of the Institute, was founded to encourage improvements in the construction or adaptation of sanitary appliances, and is awarded by the Council at intervals of three years, the funds being provided by the legacy left by the late Henry Saxon Snell. The prize in the year 1924 will consist of fifty guineas and the medal of the Institute, and is offered for an essay on "Improvements in the Sanitary Conditions of Underground Dwellings and Small Underground Workshops." Particulars can be obtained from Mr. E. White Wallis, secretary, 90, Buckingham Palace-road, S.W.1.

WATER-COOLED AERO ENGINES.*

By A. J. ROWLEDGE, Member of Council.

WHEN we consider the relative merits of various types of aero engines, it is obviously necessary to consider their qualities in relation to the work they have to perform, and the machines into which they are fitted. The aero-engine designer in most cases is not an aeroplane designer also, and often finds it difficult to place the true relative value of the various points in his engine specification. This paper commences with some notes on this matter, in the hope that they may meet with some criticism from aeroplane constructors to confirm or correct the ideas set forth.

Since the early days of flying, both the water-cooled and the air-cooled types of internal-combustion engine have been used to provide the power necessary to maintain flight. It is probable that both will continue to be used, as neither has reached the limit of its possible development, and each has special characteristics, making it especially suitable under certain conditions.

Granting this, we may claim for the water-cooled engine that almost all the great performances in the air have been accomplished by machines fitted with this type of power unit, since the days when the brothers Wright fitted a four-cylinder water cooled engine in their machine, and succeeded in making the great advance in flying with which their name is associated. Further, we may always expect that it will be possible to build a faster machine with a water-cooled engine than with an air-cooled engine. With water cooling the temperature of the engine is under better control to meet the great variations of temperature met with in flying at different altitudes. The problem of heating the mixture pipes and the carburettor is also considerably simplified.

As flight only became possible on the introduction of a motor of a sufficiently low weight per brake horse-power, it is obvious that this factor is a very important one. The whole question of suitability is almost entirely wrapped up in this one point, particularly if we could carry the consideration far enough to take the weight of the whole power plant against the thrust horse-power developed. If we leave out the question of airscrew efficiency, a statement of the case is fairly simple.

Reliability is also an obvious requirement, and one that probably all aero-engine designers would be prepared to admit must be more fully met in the future. Length of life is very much tied up with reliability, although it is a separate question. We also have to consider the question of economy in its widest application, and to take into consideration first cost, running cost, and maintenance cost. The efficiency of the engine is important, mainly as it affects the question of weight.

A great deal has been heard of engines using heavy oil, and it is assumed that such engines will increase safety and reduce fuel costs to a very considerable degree. In view of the number of machines that have caught fire in the past, the question of safety is not to be lightly dismissed. At the same time, with an engine using petrol as fuel, if properly designed and installed in a suitable machine, the risk of fire, even in a crash, is extremely small. The direct-injection heavy-oil engine is in a very early stage of development as regards its adoption for air use, and has still to make a place for itself. If the system meets with success it will solve many outstanding problems.

Water-cooled aero engines are now made in which the total weight of the engine with airscrew, cowling, radiator, water and in fact everything that needs to be added to the aeroplane, except the fuel and oil with their tanks, is less than 3 lb. per brake horse-power, and this result can be attained with engines fitted with a reduction gear to enable the airscrew to run at the most suitable speed.

Figs. 1 and 2† show the brake horse-power required to carry 1 lb. of useful load with power plants of various weights per brake horse-power. The curves are plotted for machines with total flying weights per brake horse-power of 10 lb., 15 lb. and 20 lb. Examination of these curves shows at once that for high-performance machines, low weight per brake horse-power is an essential quality, but becomes of less importance as the required performance of the machine is lowered.

The question of economy in its various aspects, covering cost of production, running costs, and maintenance costs, requires more than superficial consideration, and has to be considered in relation to the complete aeroplane. It is of little use to have an engine that can be built for a low price per brake horse-power and use a low-priced fuel if its performance is poor, and if it not only requires to be of much greater horse-power itself, but requires also a larger and more costly aeroplane to perform the same duty.

If we take the case of a commercial machine with a total flying weight per brake horse-power of 15 lb., and an allowance of 3 lb. per brake horse-power as the weight of the power plant, on the basis of these curves the engine must give 218 b.h.p. to carry 1,000 lb. useful load on a 4 hours' flight. If the total power plant weighs 5 lb. per brake horse-power, the engine must be increased to 374 b.h.p. with a large increase in the size of the aeroplane. A handicap of this magnitude must delay the coming of the day when commercial aviation will be able to be carried on without the aid of subsidies as a profitable commercial undertaking.

The dry weight of a water-cooled engine is less than the dry weight of an air-cooled engine of the same cylinder dimensions and arrangement of cylinders, but when the radiator and water are taken into account, the total weight of the water-cooled engine is greater. The water-cooled engine, however, gives rather more power for the same cylinder capacity, and at a less expenditure of fuel.

We can say most certainly that all aero engines have been designed for war purposes. That they are of use for commercial aviation shows that the conditions are at least to some extent the same for both purposes, or perhaps we should say that the requirements for some types of military machines are very nearly the same.

A successful aero-engine design is costly to produce and to place in production. The experimental models have to be built and tested for long periods to prove the design. If this is satisfactory, then jigs and tools have to be made to enable the engine to be produced at a reasonable cost. For this reason commercial aviation is handicapped, in that at present it does not demand sufficient engines of one type to enable production in such quantities as to warrant a design limited to its sole use, particularly

Fig. 1. TOTAL ENGINE WEIGHT PER B.H.P.

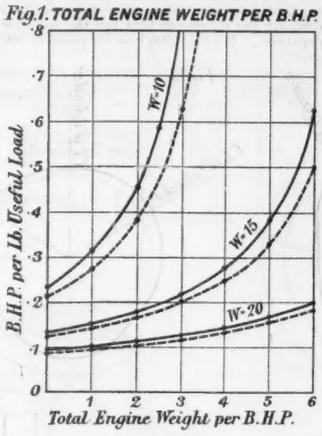
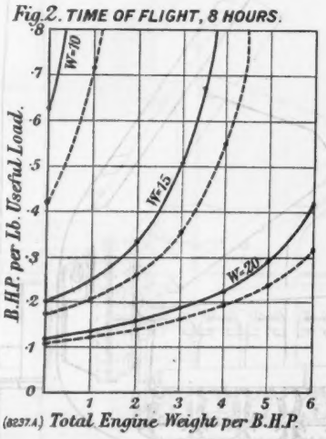


Fig. 2. TIME OF FLIGHT, 8 HOURS.



as it is improbable that only one size of engine will be required.

Water-cooled engines have been produced up to 1,000 b.h.p. in one unit in great variety of design and power. The variety of machines is even greater if we include the single-seater racer, the large multi-engined flying boat, and the airship. If we consider an engine for commercial use, we shall find that it will have most of the qualities needed for some kinds of military service, the most important difference being the need of the military machine to fly at great altitudes, which is unnecessary for commercial service at present. Fortunately compromise, which is the essence of design, makes it possible to meet fairly well all requirements without sacrificing our main design conditions.

Another subject that it is worth our while to investigate in considering the best type of aero engine, and one which will have a great effect on the type, is the provision of a variable-pitch airscrew, or the alternative of a variable-speed gear. Engine builders in the past have usually left the airscrew to the aeroplane designer, and probably each has been too busy on essential details to concentrate on this apparently difficult problem. It certainly seems unfortunate that the variable-pitch airscrew has not made more rapid progress.

The alternative, a two-speed gear, is at present being designed and constructed. A good two-speed gear does not appear to present a difficult problem, and it is probably easier to deal with than a variable-pitch airscrew. If we regard the additional weight due to the two-speed gear as negligible, the result will be greatly improved take-off and climb, and better fuel efficiency when cruising, as the engine can be run at its most economical load. It is rapidly becoming the practice of civil aviation firms to run their engines as though they were on the low gear all the time. In this case the advantages will be better fuel economy, and a great improvement in reliability and engine life, owing to the lower revolution speed and higher brake mean effective pressure when cruising, but we cannot expect to improve the climbing speed as well. The weight per brake horse-power climbing can be reduced, say, 10 per cent., an improvement well worth while. Such a gear can also be used to maintain the speed of the airscrew when flying at high altitudes, although in this case, as the engine will have to run faster, it will be at some loss of reliability, and justifiable only as a military expedient.

In commencing the design of a water-cooled aero-engine to meet given conditions, we have to decide the number of cylinders, the arrangement of the cylinders, and the bore and stroke to be adopted. For a given cylinder, to obtain the maximum efficiency, experience shows that a fairly long stroke is desirable, giving a better shape of combustion chamber. At the same time, if the stroke is too long, it becomes difficult to get suitable sized valves in the head. Also, if we take the consideration for least weight, we come to the conclusion that the stroke should be fairly long, probably a stroke/bore ratio of 1·4 being a desirable figure.

There are, of course, two schools of aero-engine design, the low-speed school and the high-speed school, the low-speed advocates generally supporting a simple six-cylinder engine, and the high-speed enthusiasts pointing to the recent racing-car engines as proof that speeds can be increased. If, however, we take one of the modern racing-car engines, and imagine that it has two pistons and connecting rods instead of one working on each crank pin, and then that its bore and stroke are increased to the same dimensions as some of the larger aero engines, it appears that some aero engines are already very high-speed machines. The piston speed of one aero engine at its rated normal revolutions is 2,375 ft. per minute.

One advantage of a high-speed engine is that it can be run at a higher compression ratio than a low-speed engine without detonating. High-piston speed and high rate of revolution are also desirable in order to keep down weight. In meeting these conditions, and the conditions for maximum airscrew efficiency, unless the aeroplane is a very fast one, it is necessary to have gearing between the engine and the airscrew, so that each may be run at its best speed. The efficiency of gearing is very high, and in fact it is difficult to get accurate measurements of the loss, which is probably not more than 2 per cent. In making reference to the brake horse-power of engines with gearing in this paper, the brake horse-power is always the brake horse-power on the airscrew shaft and not on the crankshaft. Satisfactory reduction gears can be built to weigh less than 0·25 lb. per brake horse-power.

In the report of the Safety and Economy Committee, issued by the Royal Aeronautical Society, it is suggested that the desirable airscrew speed could be calculated on the basis of some such formula as $20{,}000/\sqrt{\text{B.H.P.}}$. The actual figure quoted perhaps gives rather too low a speed for the airscrew.

In the regulations for a competition to take place in France, the airscrew speed must be less than $32{,}000/\sqrt{\text{B.H.P.}}$, and it is proposed to use the following formula to obtain the power at the airscrew :—

$$\text{Power at airscrew} = \text{B.H.P.} \times (32{,}000/\text{revs.}\sqrt{\text{B.H.P.}})^{0\cdot1}$$

This formula gives us something to work on when comparing engines of different horse-power, and with airscrews running at different speeds, but is unsatisfactory in so far as the efficiency increases indefinitely with the reduction of airscrew revolutions, whereas it should give maximum marks for an engine driving its airscrew at the most efficient speed, and deduct marks from engines in which the airscrew runs either faster or slower than the best speed.

Difficulties of this sort always occur in drawing up competition rules, but it is evident that the compilers in this case were very anxious to encourage low speed. If a complete set of regulations for a competition for aero engines were drawn up by machine designers, it would be of very great value to engine designers when deciding their programme of future development without any competition ever taking place.

Taking as an example an engine of 500 b.h.p., having its airscrew mounted directly on the crankshaft, and running at 1,400 r.p.m., the power at the airscrew by the above formula is 501. If a reduction gear is interposed between the engine and the airscrew, and we take the revolutions per minute as 893 from the formula of the Safety and Economy Committee, then, using the same formula for power at the airscrew as in the first case, we arrive at a figure of 525 against 501 in the direct-drive case. These figures look curious, but evidently the framers of the competition rule were taking a high-speed direct-drive job as their basis. Roughly, if we ignore efficiency, we can make an engine nearly 10 per cent. larger by leaving out the reduction gear, for the same total weight of power plant, but as soon as we take into account fuel consumption this figure falls rapidly, as the additional power obtained is mostly lost by the reduced airscrew efficiency, but requires fuel and cooling in proportion to the increased cylinder capacity.

The author feels that this is a somewhat vague and ineffective way of putting the matter. The question is a very involved one, and depends on so many conditions, including body effect on airscrew efficiency. In practice, he believes the results are very much more in favour of the low rate of revolution than a first investigation might suggest.

If it is accepted that gearing is essential, then it appears to be necessary to have at least 12 cylinders to keep the torque sufficiently uniform to avoid trouble in the gearing. Further, the more uniform the turning effort, the less are the stresses in the airscrew and

* Paper read before the Institution of Automobile Engineers, January 9, 1924.

† These curves are taken from a note entitled "Importance of Low Weight per Brake Horse-Power, and Low Fuel Consumption per Brake Horse-Power of the Power Plant for Aeroplanes," published in the *Aeronautical Journal* for August, 1922.

air-screw boss. Of course a flywheel could be used to keep the torque uniform, but the additional weight is undesirable. If we adopt 12 cylinders as the minimum requirement, it still leaves the question as to the maximum number open. Probably for engines up to 750 b.h.p. 12 is the most desirable number.

Having now arrived at the number of cylinders, we have to consider the best arrangement of the cylinders. The determining features are weight, head resistance, and convenience of installation. We can rule out the 12-cylinder-in-line engine, as impracticable. This leaves us the twin-six, the triple-four and the radial engine. Radial water-cooled engines of French make have been largely used, but they do not appear to be favoured in this country, perhaps because the head resistance is at a maximum in this type. There is very little to choose between the remaining two types, the twin-six and the triple-four. The twin-six has the smaller head resistance, and is the more convenient for installation, particularly with regard to its exhaust pipes. The connecting rod big end of the twin is also a simpler problem than with the three rods working on one pin of the triple-four. There is very little difference in the weight per brake horse-power, and this is due very much to the longer stroke that can be used with the twin without getting an unduly large frontal area.

The Cooling System.—Water as a medium for transferring the heat from the cylinder-wall surfaces to the radiator surface possesses many advantages to offset the apparent simplicity of direct air cooling. The high specific heat of water means that it can absorb a large number of British thermal units without its temperature rising unduly. It also prevents local hot spots in the combustion space, an important point assisting reliability and fuel economy. In addition, it enables the cylinders to be arranged in a suitable form for small head resistance due to the engine, and lends itself to body forms which give the pilot a good view, while the cylinders can be placed closer together, making the engine more compact, and of course lighter.

The latest American racing machines are examples of how the head resistance due to cooling can be reduced to a minimum by the use of this system, a result that air cooling can never attain. The weight of the cooling system adds to the dry weight of the engine about 0·6 lb. per brake horse-power for a long-range machine, including the weight of the radiator, radiator shutters, pipes, tanks and water.

The system has to get rid of from 20 B.Th.U. to 24 B.Th.U. per brake horse-power per minute. A certain amount of heat is, however, required to warm the carburettors and mixture pipes, and this is not included in the figures to be dealt with by the radiator. The provision of an alternative source for the supply of the heat necessary for this purpose in an air-cooled engine is a matter of difficulty.

The use of rubber hose for making connections in the water system may be generally condemned. Rubber should never be used unless protected by metal and in compression. Under these conditions it can be relied upon to have a reasonable life, and serve a useful purpose in providing a certain amount of flexibility in cases where it is essential to do so.

The water circulation is always maintained by a pump of the centrifugal type. The spindle of the water pump is in most engines grease-lubricated, but in the R.R. "Eagle" engine the lubrication of this part is satisfactorily effected by using the circulating water only for the purpose. The British standard rate of flow through the radiator is 15 gallons per 100 b.h.p. per minute, an ample quantity under all conditions.

It is probable that slight pressure loading of the system will be resorted to in the future to increase the efficiency by raising the maximum temperature that can be used, thus increasing the difference between the radiator and air temperatures. We may also look for possible development on the lines of the evaporative cooling experiments being carried out on American cars, but so far as the author knows the system will require a lot of spade work to make it a useful one for application to aeroplanes.

Cylinder Construction.—The different types of cylinder construction have been very well illustrated a number of times, and the questions of the best shape for the combustion chamber, desirable gas velocities, &c., have been fully discussed.* The author therefore does not propose to touch on more than a few points applying to this unit.

There are two main types for water-cooled engines, the all-steel cylinder built up from forgings, stampings and sheet-steel welded together, and the aluminium cast block with a steel liner. Each cylinder is usually a separate unit in the all-steel type, but aluminium cylinders are always made in blocks with the valve gear totally enclosed.

Overhead valves are always used for aero engines, and almost always overhead camshafts, agreeing in this respect with racing-car practice, but differing in detail due to the one having a weight limit, and the other a rating-capacity limit.

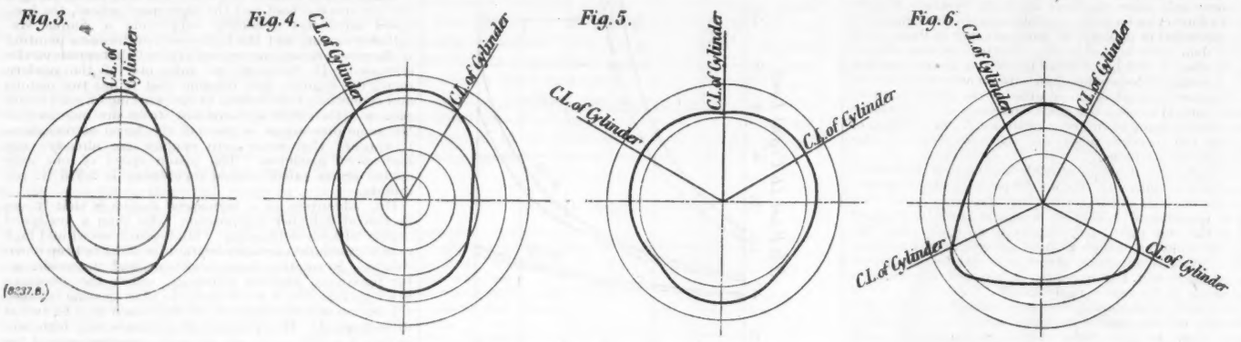
In this connection it may be remarked that we shall probably have important air races run under rating rules, in fact, unless this is done it is probable that expense will kill competitions, and certainly a limit of size for racers would not affect their usefulness as aids to progress. A beginning has already been made in the recent light-plane competition, in which the engines were limited to 750 c.c. capacity.

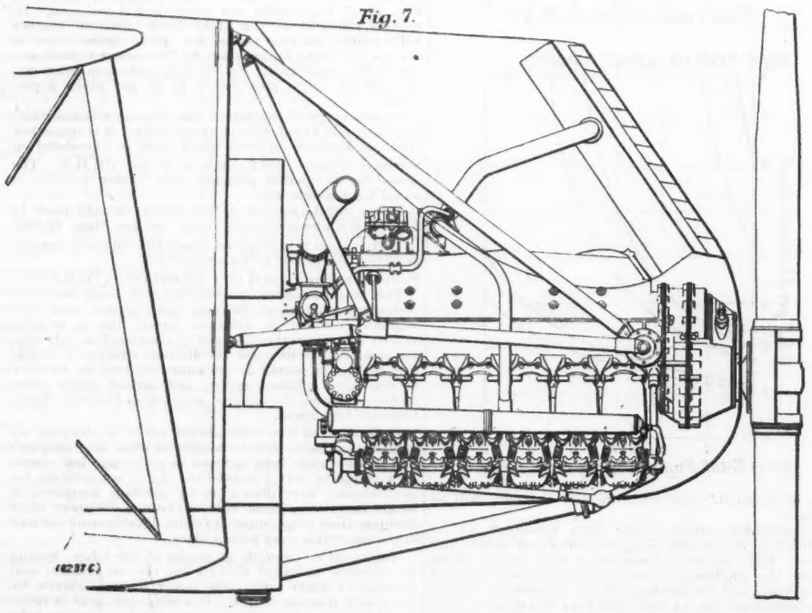
The steady improvement in valve steels is remarkable, and steel makers are to be congratulated on the success with which the problems have been tackled. The non-burning and non-corrosive qualities of some of the steels are very good, the high-silicon class being perhaps the best. A valve that does not corrode or scale keeps much cooler than one that does. For this reason, once a valve starts to fail it rapidly gets worse with increasing speed.

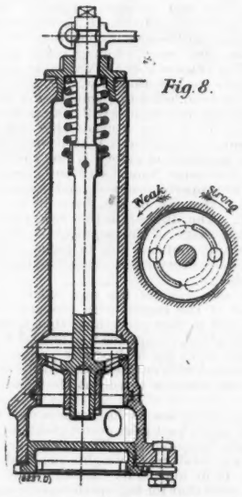
Crankshafts.—Stiffness is perhaps more important than strength in this important part. If any periodic vibrations occur in the working range of speed, the additional stresses induced due to those vibrations will cause breakdown, not only in the shaft itself but in many other parts of the engine. Indeed, the aeroplane itself will suffer if these vibrations are bad enough, and it will at all events be very uncomfortable for the occupants.

The complete stressing of a crank design is a very complicated piece of work taking many weeks, but has been developed to a sufficient point to enable crankshafts to be designed safely very close to the minimum possible weight. To illustrate part of the method, polar diagrams of big-end loading due to inertia only are shown in Figs. 3, 4, 5 and 6, for one, two, three and four cylinders on one crank-pin. These have to be developed by the addition of loads due to gas pressure taken from an indicator diagram. Afterwards the loadings on the main bearings can be drawn on separate diagrams. They must also be worked out at different speeds. It is possible for the explosion just to balance the inertia loads in a high-speed engine, and thus at the moment of explosion there is no load on the crank-pin. In another case the author remembers the explosion was just twice the inertia load, and so did not alter the amount of load on the pin, but only its direction. Big-end bearings are almost always of the plain type, but ball and roller bearings are more often used for the main journals. Most engines with more than two-throw shafts have plain bearings.

Lubrication.—There is very little variation in the lubrication systems employed by different designers, a dry sump and separate oil tank being universally used. This necessitates the use of a scavenge pump to return the oil from the bottom of the crank-case to the tank, in addition to the pressure pump drawing from the tank and supplying the bearings under pressure. Usually two scavenge pumps are fitted drawing from either end of the base to allow for the different attitudes taken by the machine in flight, without using an unduly deep sump. The features which require most care are the filters and the pipe lines. Efficient filtering will greatly increase the life of the bearings. Badly-arranged pipe lines will fracture, thus causing failure of the whole plant. By careful design the straggly type of pipe of the nut and nipple variety can be practically eliminated, much to the ease of mind of all concerned. The author







* A summary of these matters will be found in Vol. II of "The Internal-Combustion Engine," by Ricardo.

is of the opinion that much time spent in warming up could be saved if the thermometer showing oil temperature was made to indicate lower temperature than 50 deg. C. More provision than is usually made for cooling the oil and regulating its temperature is desirable. In this respect the water-cooled engine has a great advantage over its rival, in which temperatures are far more difficult to control. The speed of oil circulation is about 6 pints to 8 pints per 100 b.h.p. per minute. The faster the oil can be passed through the bearings, so long as an excessive supply does not get to the pistons, the better.

Petrol System.—This should be as simple as possible. As far as the engine is concerned, it is best if it can be arranged to have only one float-feed and no petrol pipes at all, except one to the tank. An engine-driven petrol pump is sometimes provided, and when the petrol system is such that a pump is necessary, it seems only reasonable that it should be driven direct from the engine and not by the usual windmill. Gravity feed is, however, greatly to be desired if it can possibly be obtained. The requirements specified for an engine-driven pump are usually more severe than for wind-driven ones, particularly in regard to lifting the fuel from a tank a considerable distance below the engine without preliminary priming. Otherwise the problem is not difficult, except as regards the gland. This is usually made with an oil seal, a certain amount of the oil leaking into the fuel through the pump and being burnt in the cylinders. If the main tank cannot feed the carburettors by gravity, it is usual, and appears to be necessary, to have a small tank sufficiently high up to feed by gravity. This tank is fed by the pump from the main tank, an overflow pipe returning the excess fuel and preventing the small tank being overfilled. A good petrol filter is required, but does not present much difficulty.

Engine Suspension.—The design of the engine suspension affects the design of both the engine and the aeroplane. The main requirements are stiffness, provision for easily removing and replacing the engine, and accessibility to all parts of the engine requiring attention in the aeroplane, such as oil and petrol filters, sparking plugs, magnetos, &c. It is quite possible to get some parts of the framework so stiff as to put undesirable loads on the crank-case. Certainly the torque reaction should be taken as near to the airscrew end as possible. Some engines to some extent rely on the engine bearers for stiffness, but it is surely much better to make the engine stiff enough itself, so long as the additional weight is not more than can be saved in the aeroplane structure by so doing. Sometimes the engine builder blames the aeroplane maker for failure of his crank-case, due to machine stresses being taken through the engine feet. This is, of course, a matter for close co-operation between both branches. On the whole it seems desirable to make the crank-case stiff enough to act as a tie between the bearers. In Fig. 7, an installation of the "Condor III" is shown, and it will be noted that the usual idea of bearer bars has been discarded.

Fig. 10.

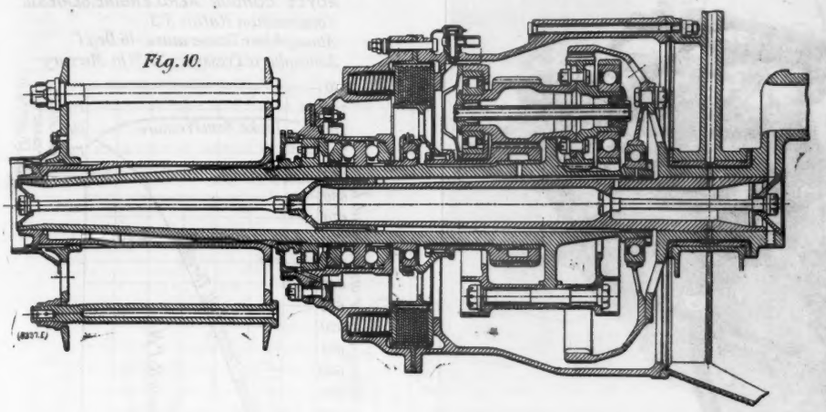
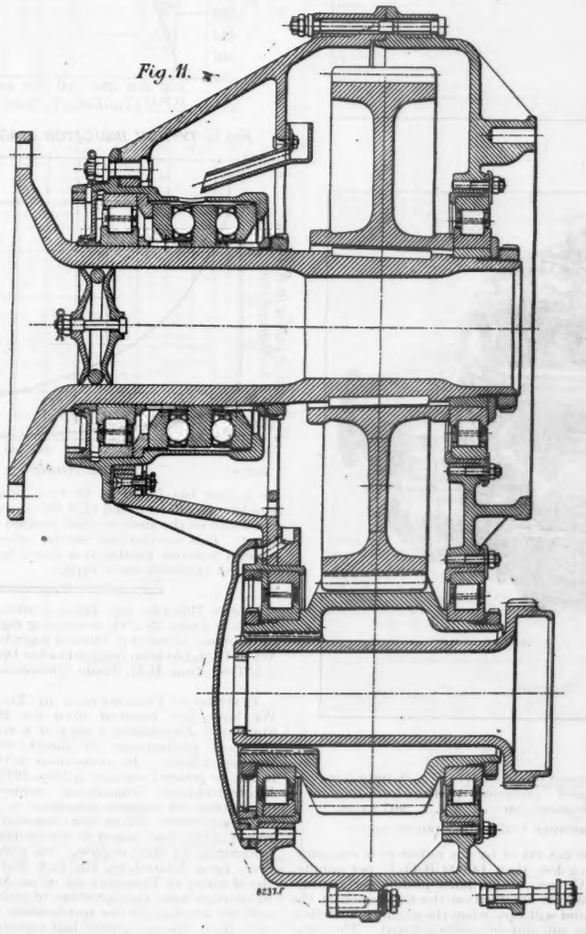


Fig. 11.



Ignition.—The use of two magnetos is almost the universal practice, and as it permits the whole of the ignition system to be duplicated from the electrical generator to the sparking-plug, this scheme is strongly to be recommended. On seaplanes and flying boats difficulties arise in keeping the sparking plugs and insulation dry, condensation as well as direct spray giving a great deal of trouble. This trouble is considerably increased by the metal screening insisted upon by the wireless section as necessary to prevent the wireless instrument from being interfered with by the waves sent out from the ignition system. The range of control that needs to be provided for timing the spark on aero engines is small compared with motor car engine requirements, and the most satisfactory way appears to be to connect it to the throttle control. If this is suitably carried out it will give the best possible engine results, save complications, and relieve the pilot of one item requiring his attention.

Carburation.—The problem of the aero engine carburettor is in some respects much simpler than for motor-car work, as the range of working speed is less, but it is greatly complicated by the need to work in varying air densities. It is comparatively easy to get good results on the test bench, but less easy to obtain them in the air, so much so that for commercial machines it is not unusual to cut out the pilot's control of mixture strength for altitude. The Claudel-Hobson and Zenith carburettors are the types generally employed, and these give fairly constant mixture strength at different throttle openings and are not likely to give trouble due to sticking valves, &c. The usual method of control for mixture strength is by a valve controlling a passage connecting the balance pipe between the intake pipe and the float-chamber to a point in the choke-tube, but in the R.R. type Claudel-Hobson the main jet itself is controlled as shown in Fig. 8, which illustrates the latest type of valve.

Airscrews.—The airscrew boss is usually the only part of the airscrew with which the engine designer deals. The form of the blades is very specialised design work, and for the same engine has to vary with the type of machine in which it is installed, and according to the speed of the machine and the diameter that can be used, owing to limitations of clearance. This prevents the standardisation of an airscrew to suit any particular engine under all circumstances. Until recently the usual type has been a wooden airscrew, with metal boss. For the latter, standards have been laid down, and appear in the British Engineering Standards Association Specifications. The metal airscrew is rapidly coming forward, and an example is illustrated in Fig. 9.* The one shown is the Leitner-Watts, and is 16 ft. across the tips. In this type the boss is bolted to a flange on the airscrew shaft, and it is intended to remove the blades individually for dismantling and transport instead of handling the complete airscrew. A four-bladed airscrew of the usual wood construction for a large engine is very much more difficult to handle.

Gearing.—The two successful types of gear reduction that have been developed are the epicyclic and the straight spur. The epicyclic has the advantage of putting much less strain on the crank-case, depending on the design, and with the usual design of engine supports puts much less strain on the supporting framework. By modification in the design of the system of carrying the engine in the frame, the simple spur type can be arranged so that the maximum load on the framework is only that due to the torque reaction of the airscrew, as in the case of the epicyclic gear.

The question of the desirability of using gearing has already been referred to, but there is also the question of central engine room arrangements, using a number of engines either coupled together and driving a single airscrew, or driving airscrews in the wings. The weight of the necessary clutches and gearing appears to be too great a handicap to make the scheme likely to be of much permanent use, and the author is of the opinion that the use of a number of power plants each complete in itself placed in suitable positions is more likely to be successful in providing maximum freedom from engine breakdown without sacrificing efficiency. The two types of gearing are illustrated in Figs. 10 and 11. Fig. 10 shows the epicyclic gear of the R.R. "Eagle," and Fig. 11 the plain spur of the "Condor" Series III.

Fuel.—The fuel question is a very tantalising one for the engine designer, because fuels vary so much in their capability of standing high compression without detonation. By using special fuels he can obtain striking results, but if he hopes that his engines will be generally used, he must content himself with the efficiency that

* This figure is not reproduced in the copies of the paper issued by the Institution of Automobile Engineers.

can be obtained with ordinary commercial fuels, and use all this skill to make an efficient cylinder design; that is his job. The variation in fuels to-day is considerable, and the designer would feel much safer if it were possible for him to know the worst fuel that will be used. The effects of detonation, if allowed to continue, are disastrous. Much more is known to-day with regard to this subject than previously, and much has been published. Our particular aim is to design our engine so that with a given fuel it shall stand the highest possible compression ratio without suffering from detonation. At the same time the general improvement of fuels opens up great possibilities, and it is probably along this path that the greatest steps to economy will be made in the near future.

Supercharging.—This subject has been so thoroughly dealt with by other writers* that it is not proposed here to do more than put in a word for the gear-driven blower and also for the separately-driven one. In the case of multi-engined machines, the latter has several advantages. The author is of the opinion that the disadvantages of the red-hot exhaust pipes, which are required to hold pressure, apart from the turbine difficulties and the extra heat at the exhaust valves, make it desirable to spend some of our energies in developing the mechanically-driven blower. Probably this type reached its maximum development in Germany in 1918, since when it appears to have been badly neglected.

* Particularly the paper by M. Rateau, published in the Proceedings of the Institution of Mechanical Engineers. See ENGINEERING, vol. cxiv, pages 91, 123.

Condor III.—Figs 12 and 13 show the "Condor" Series III engine, the leading particulars of which are given in the following table:—

Number of cylinders	12.
Bore	5½ in.
Stroke	7½ in.
Normal brake horse-power ...	650.
Normal speed (crankshaft) ...	1,900 r.p.m.
Maximum speed (crankshaft) ...	2,100 r.p.m.
Normal speed (airscrew) with 0·477 reduction-gear	907 r.p.m.

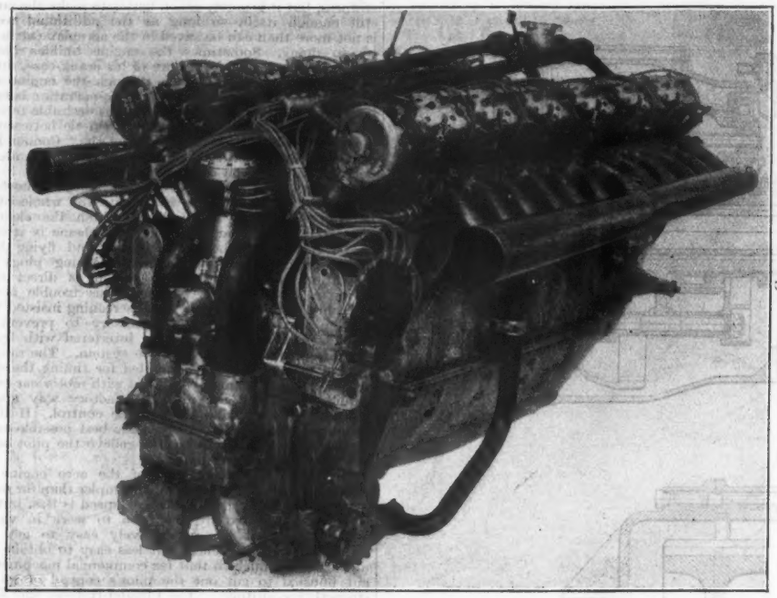


FIG. 12.

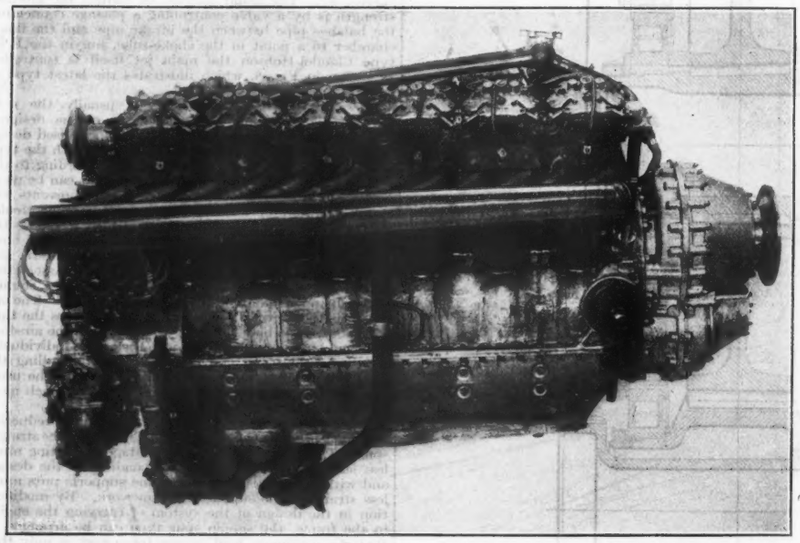


FIG. 13.

Fig. 14 is an average brake horse-power curve.

The heat to be got rid of by the radiators is comparatively small, being less than 14,000 B.Th.U. per minute, or 21·54 B.Th.U. per brake horse-power per minute. This figure is the one obtained on the test bench at the makers' works, and will vary when the engine is installed, according to the amount of cowling fitted. The total dry weight of the engine complete is 1,320 lb.

The average fuel consumption during the 50 hours' run of the official type test was 0·483 lb. per brake horse-power per hour.

Several of the fittings shown can be dispensed with for civil work. The fire-control gear for guns firing through the path of the blades of the airscrew, located at the front end of the crankshaft, for instance, will not be required. An engine-driven petrol pump is fitted on the engine shown, but is only supplied when required. The carburettors are at the rear of the engine in a position which facilitates gravity feed. The air intakes are self-draining, and are led to the outside of the fuselage. Each side of the engine has its own complete system, the air intakes being taken out, one on each side of the machine, thus considerably reducing the risk of fire in the event of back-firing from any cause, as in the event of one side being choked, the other will keep the engine turning and suck out the fire.

A typical indicator diagram is shown in Fig. 15. This diagram was taken with the Norman indicator, which the author has found to be very reliable and easy to handle. It will be noted that the airscrew boss is bolted to a flange on the airscrew shaft instead of the usual flange fixing. This method has several advantages, and with a metal airscrew results in a much lighter construction than the extended shaft type.

Fig. 14. BRAKE HORSE-POWER CURVE FOR ROLLS-ROYCE "CONDOR" AERO ENGINE, SERIES III. Compression Ratio - 5·3 Atmospheric Temperature - 16 Deg. C. Atmospheric Pressure - 29·97 In. Mercury

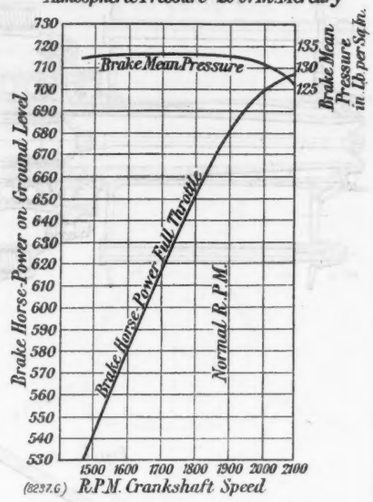
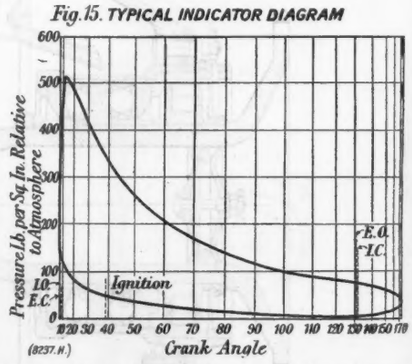


Fig. 15. TYPICAL INDICATOR DIAGRAM



INDIAN BOILERS ACT REGULATIONS.—A copy of the *Gazette of India*, No. 43, containing regulations issued by he Governor-General in Council regarding the Boiler Law Act of 1923, has been received at the Department of Overseas Trade from H.M. Trade Commissioner at Calcutta.

ELECTRICAL PERFORMANCE OF TRACTION MOTORS.—We have just received from the British Engineering Standards Association a copy of a specification for the electrical performance of direct-current series-wound traction motors. In connection with this publication it may be pointed out that in May, 1919, the International Electrotechnical Commission requested the national committees of various countries to prepare proposals for temperature limits for traction motors, and the specification now issued is the response of the British Committee to that request. Its publication has, however, been delayed by the fact that, in March, 1920, the Ministry of Transport set up an Advisory Committee to enquire into the question of railway electrification and the drafting of the specification was not proceeded with until this committee had reported. The specification contains sections relating to definitions, types of enclosures, classes of rating, limits of temperature rise, commutation, efficiency, high-voltage tests, performance and type tests, information to be given on the name plate and to be supplied by the maker, and information to be given to the maker with enquiries or orders; appendices to the specification deal with the classification of insulating materials, temperature measurements, and the relation between tests and temperatures of motors in service. The publication can be purchased through any bookseller or direct from the offices of the British Engineering Standards Association, 28, Victoria Street, S.W. 1, price 1s. net, or 1s. 2d. post free.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

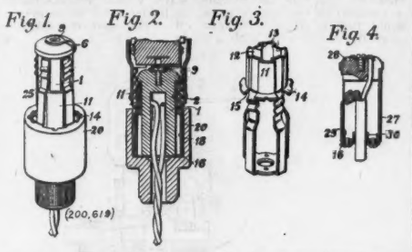
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

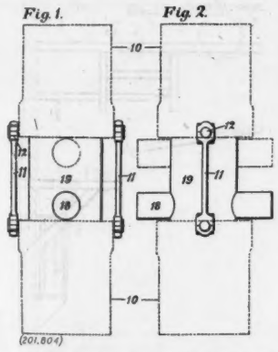
200,619. W. E. Shore, New York. Electric Plug Connectors. (7 *Figs.*) April 29, 1922.—A screw-plug connector comprises a central insulating member 1 around which are arranged thread-engaging contact fingers 18 adapted to be expanded simultaneously outwards against the threaded wall of the socket by a longitudinally-movable member 20. The member 1 is formed with longitudinal grooves 2 in which are mounted ribs 12 sliding on a metal sleeve 11. The lower end of this sleeve is formed with a flange 14 by which it is secured to the member 20, and the flange is cut away in line with the ribs 12 forming radial slots 15. The fingers 18 are formed on a metal disc 16 secured to the lower end of the member 1. They are



curved transversely and formed with transverse thread corrugations to fit the thread of the socket. The upper ends of the ribs 12 are curved in as shown at 13 and the bevelled ends thus formed serve to expand the fingers 18 against the socket upon movement of the member 20 towards the member 1. One circuit wire is secured to a terminal 25 which is disposed in a slot in the member 1 and is in conducting connection with the disc 16, and the other wire passes through a slot 6 in the member 1 and is secured beneath an end contact washer 9. In a modification, Fig. 4, the member 1 is formed as a metal cylinder 27 carrying at its outer end an insulating cap 28 and at its inner end a flanged plate 29 between which and the disc 16 is secured an insulating bushing 30. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

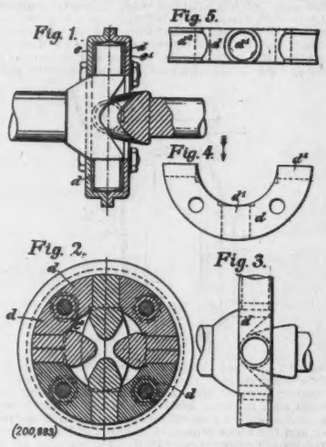
201,804. North British Diesel Engine Works (1922), Limited, Whiteinch, Glasgow, and J. C. MacC. Maclagen, Drumchapel. Internal-Combustion Engines. (3 *Figs.*) September 21, 1922.—The invention relates to that type of double-acting cylinder in which is a trunk piston operating a gudgeon pin passing out through gaps in the cylinder walls. A cylinder element made according to the invention comprises essentially two end members connected together at their inner



ends by a separate and comparatively light structure permitting of the protrusion of the gudgeon-pin. The cylinder end members 10 are connected with one another by two diametrally-opposed links 11 lying parallel with the axes of the cylinder parts, external to them, and pivoted at their ends upon trunnions 12 which may be either formed upon or secured to the cylinder. This method of support provides ample space for the protrusion of the gudgeon pins 18 (dotted as at the opposite ends of their stroke) of the piston 19. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

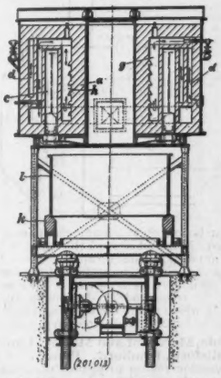
200,883. Sir H. Austin, Bromsgrove. Shaft Coupling. (5 *Figs.*) April 18, 1922.—The invention relates to universal shaft couplings of the type in which each shaft end has a pair of horns or trunnions with their common axis laid across the shaft end, the trunnions of the two shafts being at right angles and entering corresponding radial holes in a ring or casing. The ring of the coupling, according to one form of the invention, is built up of two sections *d* laid with their ends together and bolted between two cover plates *e*, *e1* by bolts passing through the sections and through the cover plates. Each section *d* at each of its ends has a half-cylindrical depression *d2* so arranged that the depressions of two abutting ends form a radial hole to receive one of the trunnions of one of the shafts. The trunnions of the other shaft pass into radial holes *d1* formed through the middle of each section. According to an alternative arrangement, the ring is built up of four sections in which case the trunnions of both shafts lie in radial semi-cylindrical depressions at the ends of the



sections, the radial holes through the middles of the sections being dispensed with. The cover plates *e*, *e1*, each have a central hole *e3* through which the corresponding shaft end passes, and such hole is of sufficient diameter to allow of a certain amount of angular movement of the shaft in relation thereto. (*Sealed.*)

MINING, METALLURGY AND METAL WORKING.

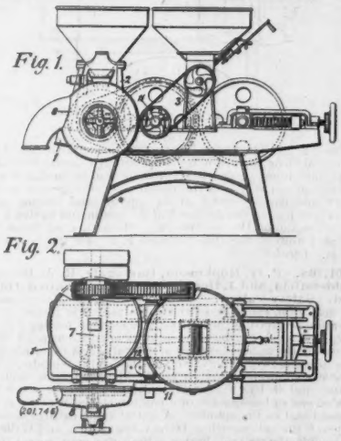
201,013. Woodall, Duckham and Jones (1920), Limited, London, and Sir A. McD. Duckham, London. Furnaces. (3 *Figs.*) July 5, 1922.—According to the invention, a furnace for heating cylinders is constructed as an annular muffle furnace *a*, the bottom *k* of which is adapted to be lowered from the furnace to receive the cylinder *l* and to be raised again so as to introduce the cylinder into the annular muffle chamber. The annular



chamber *c* is preferably surrounded by vertical flues *d*, *g*, *h* so arranged that combustion occurs on the inner or outer side, or on both sides, of the annulus in flues which alternate with waste gas flues. The bottom *k* is supported on rams capable of being raised and lowered hydraulically. When the weight to be carried by the bottom is not considerable the rams may be constructed as racks and operated by pinions driven by an electric motor through suitable reducing gear. (*Sealed.*)

MILLING AND SEPARATING MACHINERY.

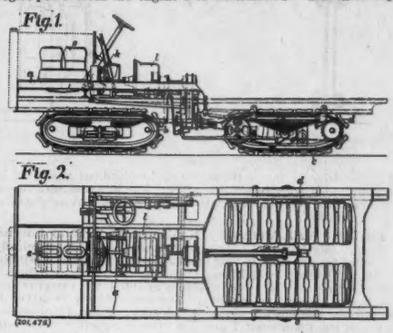
201,746. R. J. Hunt, Earls Colne, and R. Hunt and Co., Limited, Earls Colne. Grinding and Crushing Mill. (2 *Figs.*) July 17, 1922.—The invention relates to grinding and



crushing mills of the type having a pair of crushing rollers and a disc grinding mill associated in a single machine. According to this invention, a bedplate is arranged having upon it bearings for the shaft of a fixed position crushing roller, while at one end a pair of bearings is arranged for the shaft of a grinding mill, the two shafts being connected together by spur gearing, so that by putting driving pulleys or their equivalent on one or the other, for example, the grinding shaft, rotating motion is conveyed to the other shaft, the proportions of the gearing being so arranged that correct speeds are obtained for each of the mechanisms. The bed plate 1 is provided with standards 2, 3 for the support of a hopper and feeding apparatus for the grinding mill and the crushing mill respectively. The bed plate also carries a driving spindle 7 on which is mounted the rotating disc 8 of a grinder, the other disc being fixed; the spindle 7 is provided with fast and loose pulleys. The bed plate 1 also carries a driving spindle 11 on which is mounted one of the crushing rollers 12. The spindle 11 is driven from the spindle 7. (*Sealed.*)

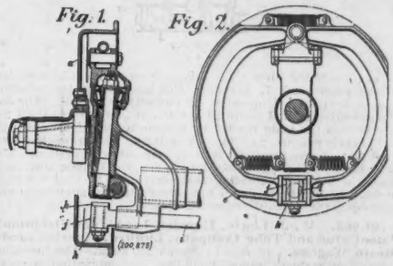
MOTOR ROAD VEHICLES.

201,475. H. C. Clark, London, and A. H. Huddart, London. Self-Laying Track Vehicles. (6 *Figs.*) August 19, 1919.—The invention relates to vehicles of the self-laying track type. A main frame or body *a* is mounted upon three bogies or trucks *b*, *c*, *d*, each of which consists of a framework surrounded by a self-laying track. The two rear bogies *c*, *d* are arranged side by side under the rear portion of the frame so that the weight of the useful load is utilised to increase the adhesion and to such bogies power from the engine *e* is transmitted. The third bogie



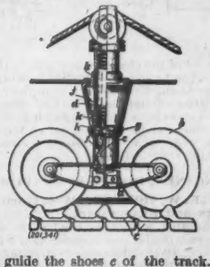
b is mounted beneath the forward end of the frame *a* and is carried on a sub-frame, being provided with rollers carried upon radial arms so that the bogie may ride upon a turntable in order that it may be capable of angular displacement about a vertical central axis whereby steering may be effected. The prime mover *e* for the vehicles may be of any known type, and in conjunction with a clutch *k* and a gear-box *l* is mounted on that part of the frame *a* immediately above the forward bogie. (*Sealed.*)

200,875. G. H. Lanchester, Birmingham, and the Lanchester Motor Company, Limited, Birmingham. Motor Road Vehicle Brakes. (3 *Figs.*) March 21, 1922.—The invention has for its object to provide improved means for operating brakes of the drum type on the front or steering wheels of motor road vehicles. The invention comprises the employment in conjunction with the expansible or contractible member or members *e* of the brake which co-operates with the inner or outer periphery of a drum *a* on a road wheel, of an operating shaft *i* which can rotate about a horizontal or approximately horizontal



axis, and a brake operating member which is carried on the shaft and can rotate relatively thereto only about a pivot, the axis of which is at right angles to the operating shaft and in alignment or approximately in alignment with the pivot axis of the wheel. The brake operating member consists of a stem *j* mounted in a socket at right angles to the shaft, and a pair of plates or collars *k* at opposite ends of the stem for co-operating with the free ends of the brake segments *e*, the end of the shaft and the brake operating member being located between the free ends of the brake segments. (*Sealed.*)

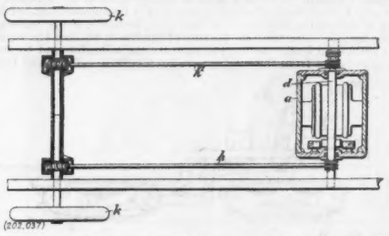
201,341. Armstrong Siddeley Motors, Limited, Coventry, and S. M. Viale, Coventry. Vehicles having Self-Laying Tracks. (3 *Figs.*) June 14, 1922.—The invention relates to vehicles having self-laying tracks. The bogie *a* carries two



wheels *b* which guide the shoes *c* of the track. According to part of the invention each bogie has a ball and socket supporting connection with the plunger *d*, the joint shown comprising a ball *e* on the bogie engaging a socket *f* in the lower end of the tubular plunger. In one method of applying spring pressure to the ball *e*, the latter carries attached to or integral therewith

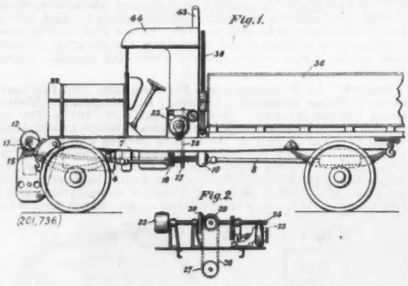
a nose or stem *g* which engages the underside of a cup *h* sliding inside the tubular plunger *d* and acted upon by a spring *j*. The underside of the cup which is engaged by the nose is so shaped in relation to the centre of the ball *e* that it constitutes a cam of any desired shape, such that when the ball moves about any desired axis the cup *h* has to move against the spring *j* and the desired resistance to it is obtained. In the preferred construction, there is arranged along the side of the vehicle a series of compartments in each of which is centrally arranged a vertical guide *k* wherein slides the plunger *d*. It will be clear that, by means of the ball and socket connection of the bogie with the plunger, the bogie can rock about an axis transverse to the track, so that the track can be perfectly flexible. The bogie can also twist about an axis parallel to the track so that the shoes of the track can accommodate themselves in the manner required. (*Sealed.*)

202,037. F. Crawford, Benwell, Newcastle-on-Tyne. Electrically-Driven Road Vehicles. (3 *Figs.*) May 11, 1922.—According to the invention, the motor *a* is mounted on a transverse axis *d* parallel to that of the pair of driven road wheels *k*



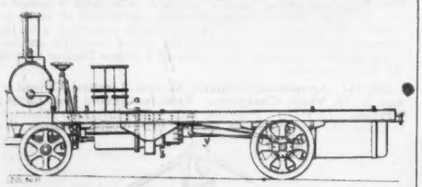
and the drive is taken through two longitudinal shafts *h*, *h*1, each provided with two worm gears. The inclination of one of the worms for one wheel is relatively reversed to that for the other wheel. (*Sealed.*)

201,736. W. J. McCarthy, Kenilworth. Tractor Lorries. (3 *Figs.*) July 12, 1922.—The invention consists of a mechanically-propelled tractor lorry having in combination therewith a winding drum for haulage and lifting purposes, a pump, an industrial drive, a tipping body, and a frame adapted for carrying long lengths of timber and the like. The tractor lorry is driven by an internal combustion engine 4. A coupling box 10 interposed between the main shaft 7 and the propeller shaft 8 enables the main shaft 7 to be disengaged from the propeller shaft 8 when it is desired to employ the engine for driving the auxiliary fitments. The winding gear comprises a winding drum 12 driven by a



worm 15 mounted on a shaft driven from a pinion 19 mounted on the main shaft 7, a sliding clutch enabling the winding gear to be rendered operative or inoperative at will. The industrial drive 22 and pump 23 are driven from a cross-shaft 24, driven from the main shaft 7 by a sprocket wheel 27, chain 28 and bevel pinions 29, 30. A suitable clutch enables the shaft 24 to be rendered operative or inoperative as desired. The lorry body 36 is adapted for end tipping, the tipping gear comprising a horizontal rotating shaft driving a vertical screw 38 through bevel wheels, and a nut secured to the lorry body and traversing the vertical screw 38. (*Sealed.*)

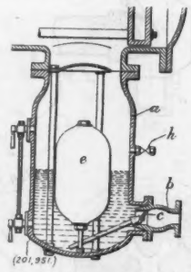
201,963. W. J. Lewin, Hunslet, Leeds, and Deighton's Patent Flue and Tube Company, Limited, Hunslet, Leeds. Steam Wagons. (6 *Figs.*) March 29, 1922.—The invention consists in a steam wagon, including in combination, a steam engine *a*, the axis of whose crankshaft is disposed longitudinally in relation to the frame of the vehicle, change-speed gearing contained in a casing *b* spigotted into the engine crank-case, a boiler water feed pump driven by an eccentric from the slowest



running gear wheel of the change-speed gear, a rigid tube *y* which is mounted at its front end on a spherical housing on an extension of the speed gear casing *b* enclosing a propeller shaft, and serving to relieve the latter of end thrust and of stress due to driving torque, and a rear axle casing *t* containing a double reduction gearing and differential mechanism, all of the casings being in communication with each other, so as to constitute a single oiltight containing space. (*Sealed.*)

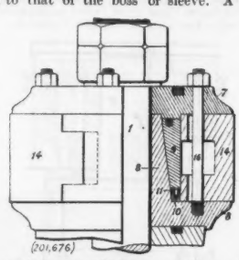
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

201,951. W. E. W. Millington, West Gorton, Manchester. Water Heaters and Evaporators. (2 *Figs.*) February 16, 1922.—The invention relates to condensate discharging apparatus, specially suitable for use in connection with water heaters, evaporators, &c. In condensate discharging apparatus constructed according to the invention, the liquid outlet *b* from the float chamber *a* is controlled by a balanced valve *c* of the butterfly or wing type, which will not be pressed against a seat or seats by the fluid pressure obtaining in the float chamber, but will, on the contrary, be balanced in all positions and will therefore at once respond to vertical movement of the float *e* to which it is connected, due to slight variations in the level of the condensate in which the float is suspended. Such balanced valves are never liquid tight, but will, on the contrary, always allow condensate to escape from the float chamber in a continuous stream. Such a balanced valve is directly connected to the float *e* in such manner that it will at once respond to every movement of the float and so that when the condensate is at the desired level, the minimum continuous discharge of condensate will take place, the valve opening to a greater extent, to permit of a greater outflow of condensate, when a greater inflow of



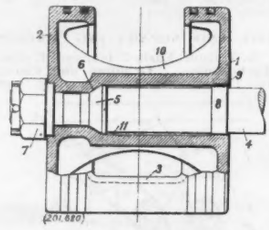
condensate to the float chamber takes place. In this way the level of the condensate in the float chamber will be maintained approximately constant under all conditions of working and there will always be a sufficient head of condensate above the outlet for the condensate to prevent escape of steam from the float chamber and the water heater, evaporator or like apparatus, to which the float chamber is connected. The requisite air outlet *h* may advantageously be arranged slightly above the maximum level of the condensate and may either be fixed or vary in position with the movement of the float. (*Sealed.*)

201,676. J. Kirkland, Liverpool. Pistons. (9 *Figs.*) May 18, 1922.—A piston, according to the invention, comprises upper and lower discs 7, 8, on the lower 8 of which discs there is formed or provided a boss or sleeve which is bored to receive a piston rod 1 and the exterior whereof is of tapering or conical shape—tapering inwardly from the lower end; a collar 9, constructed in one or more parts is disposed around the boss or sleeve, the central passage of which collar is of reverse taper or conical configuration to that of the boss or sleeve. A piston ring 14



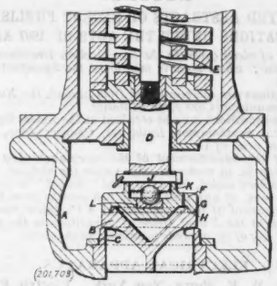
in one or more parts (and on which upper and lower ring extensions may be provided) is placed around the collar 9; and a number of liners 10, 11 are disposed one on another below the bottom end of the collar 9 and the adjacent surface of the lower disc 8. The arrangement is such that by removing a liner or liners, placing same on top of the collar and "re-hardening up" the piston by means of studs 16 which secure the upper and lower discs together, the piston ring may be expanded as required. (*Sealed.*)

201,680. Cole, Marchent and Morley, Limited, Bradford, and R. S. Brailsford, Bradford. Piston. (2 *Figs.*) May 20, 1922.—The invention relates to pistons particularly suitable for what is known as uniflow engines. According to the invention, the piston is firmly connected at one end only to the piston rod 4 over a short length, and has at its opposite end a short axial cylindrical guide surface on said piston rod allowing for full relative expansion of the parts. The piston is made up of two end portions 1, 2, united by a skirt portion 3 integral with the



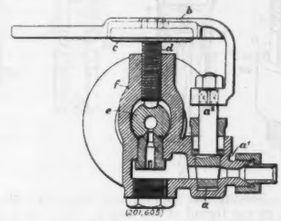
portions 1, 2. The piston is mounted on the piston rod 4 in that a cone part 5 on the piston rod 4 fits within a similar conical part 6 of the piston end 2, and is secured thereon by means of a nut 7. The piston rod is free of the piston along the greater part of its length and has a collar 8 at its opposite end bearing within a turned out part of the portion 1 of the piston and having a feather key 9 engaging the portion 1. Strengthening webs 10 are provided uniting the two portions 1, 2, and the boss 11 of the piston. (*Sealed.*)

201,708. P. G. Hopkinson, Harrogate, R. A. Hopkinson, Huddersfield, and J. Hopkinson and Co., Limited, Huddersfield. Safety Valves. (1 *Fig.*) June 14, 1922.—According to the invention, the back of the valve proper is furnished with a flat annular faced surface directly above the seating face of the valve, and a cap having a flat annular bearing surface is provided to bear on the annular surface of the valve and to form a separate loose piece between the valve and the loading spindle. The cap is loosely connected to the spindle by a transverse bolt or like means, and it has a central bearing surface for receiving the pointed end of the spindle, or a ball interposed between it and the recessed end of the spindle. A is the valve casing, B the valve proper, C the valve seating, D the valve spindle, and E the springs for loading the valve. Between the valve spindle and the valve proper is interposed a separate loose piece F having a faced annular surface at G adapted to bear upon a correspondingly-faced annular surface H provided on the back of the valve adjacent to the periphery thereof, and directly above the seating. The cap F is loosely connected to the valve spindle by a transverse bolt J passing through the upper cup-shaped part of the cap and



through the spindle. The load on the spindle is shown transmitted to the cap through a ball K which rests between the recessed end of the spindle and a recessed hardened bearing-piece L inserted into the back of the cap. (*Sealed.*)

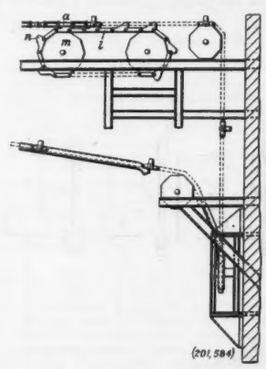
201,605. A. Laing, Newcastle-on-Tyne. Oil Fuel Burner. (3 *Figs.*) April 24, 1922.—The invention relates to a liquid fuel burner fitting of the type including a burner holder carrying a shut-off cock or valve and equipped with a pinching screw serving to hold the burner joint on its seat, there being an interlocking connection between the valve-operating member and the hand wheel for operating the pinching screw which prevents release or removal of the burner from the holder until the supply of liquid fuel is completely shut off. The shut-off cock *a* is operatively connected with a cover *b* adapted to enclose sub-



stantially all round the hand wheel *c* for the pinching screw *d* of the burner *e*, so that, when the shut-off cock *a* is open, the hand wheel *c* is inoperable, and when the hand wheel *c* is rotated to loosen the pinching screw *d*, the cover *b* functions as an interfering element fouling the hand wheel *c* to prevent movement of the cock *a*. The cock casing *a*1 is formed as part of the burner holder *f*, the interior of the casing being connected with the interior of the holder by a passage-way formed in the casting, and the spindle *a*2 of the cock *a* is connected to an arm extending from the cover *b*, the cock *a* being of the straight through type. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

201,584. J. W. Pacey, Eastwood. Chain Haulage Railways. (5 *Figs.*) March 1, 1922.—The invention relates to chain haulage railways of mines of the kind in which a slow travelling endless plate chain is employed (usually termed a "creeper") and is provided with projections or fingers to engage with and



move the wagons along the rails. According to the invention the haulage chain *a* is driven by means of a short endless supplementary chain *l* which is carried and driven by means of sprocket drums or pulleys *m*, and this short chain is provided with teeth or projections which are adapted to engage between alternate links of and drive the main chain. (*Sealed.*)

DAY LABOUR TUNNEL COSTS IN CHICAGO.—According to *The Engineering News-Record*, New York, work on the 12-ft. Western-avenue water tunnel has been under way since 1919. In the 1922 annual report of the Water Department just issued, excavation progress on 7,977 lineal ft. at the Wood-street shaft is given as 10·81 ft. per 8-hour shift, at a cost of 55·52 dols. per lineal foot, including labour and explosives. Trimming 9,224 ft. cost 1·05 dols. per foot. Placing footing walls in 7,730 ft. cost 1·65 dols. per foot. Costs were less at the 61st Street shaft, where 9,778 ft. were driven at a cost of 54·06 dols. per foot, 5,327 ft. of footing walls placed for 83 cents and trimming 6,957 ft. cost 41 cents per foot.